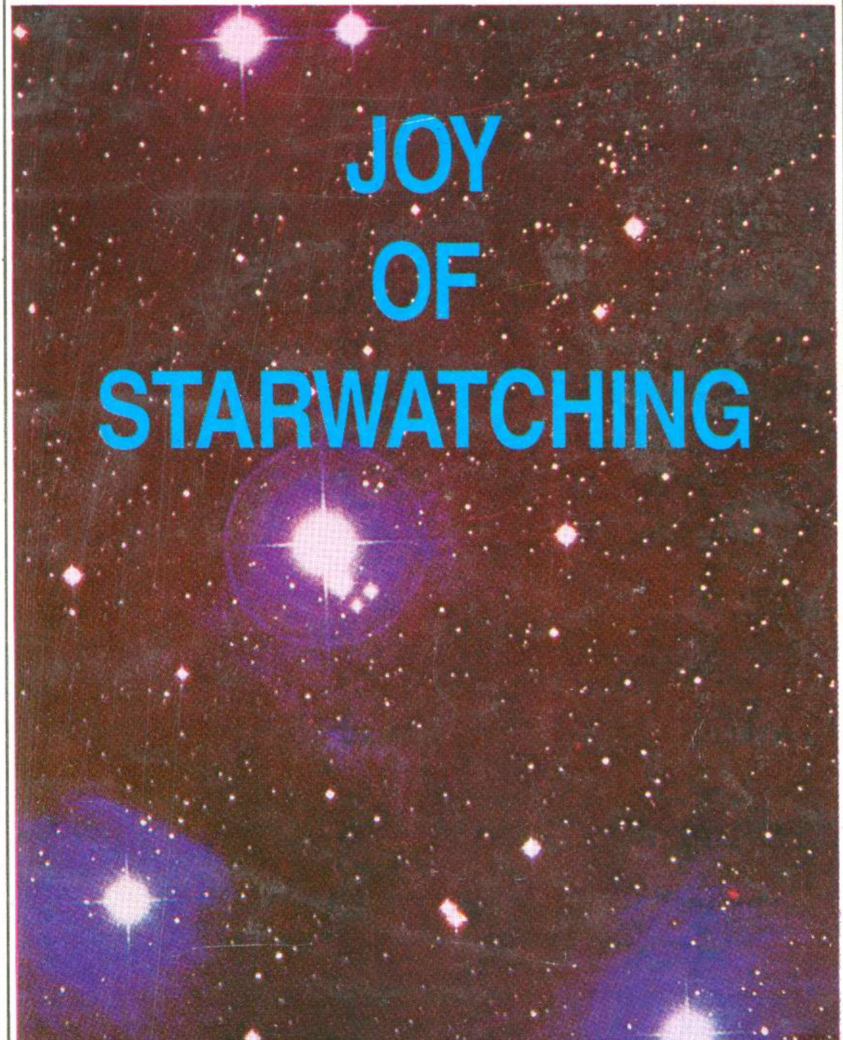
POPULAR SCIENCE



JOY OF STARWATCHING

BIMAN BASU

Popular Science

Joy of Starwatching

Written and Illustrated by

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NATIONAL BOOK TRUST, INDIA

ISBN 81-237-2657-0

First Edition 1999 *(Saka* 1920)

Published by the Director, National Book Trust, India
A-5 Green Park, New Delhi - 110 016

To

Prof. Amalendu Bandyopadhyay
for all his encouragement in my
astronomical ventures

Contents

Preface

The star-filled night sky has fascinated me since my childhood days when, sleeping on a *charpoi* (cot) under the open sky in summer, I could watch the constellations pass overhead as the night progressed. Delhi sky in the 1950s was not as polluted as of today and on a moonless night one could clearly see the majestic Milky Way straddling the sky from north to south in some seasons. Gradually, with quite some effort, trying to decipher the star maps that were published every month in the local daily, I learnt to identify a few of the prominent constellations and bright stars. Later in life, my familiarity with the constellations helped me a lot in locating the planets and several comets including the famous Halley's comet in 1985 when it was still far away and had not yet developed its characteristic 'tail'. In course of time, as I acquired a telescope, the views of the crescent phases of Venus, Jupiter's moons and Saturn's rings and several beautiful double stars and star clusters enthralled me.

In the meantime, my interaction with readers as editor of *Science Reporter,* which published a sky map every month, brought to light the fact that the conventional sky map is pretty difficult to interpret for the purpose of identifying the constellations, at least for the uninitiated. It was then that the idea of writing this book took its root. I could realise that rather than a whole sky map showing

the constellations, many of them in grossly distorted shapes, it would be far better to begin with a few prominent constellations which can be recognised easily and then use their stars as direction finders to locate other, less prominent constellations. I have found this technique to be quite convenient and useful and hope the readers would also find it so. This technique is particularly useful as it does not restrict the observer to any particular sky map which is usually meant for a particular month and a particular latitude whereas the Indian landmass extends from around 8°N in the south to almost 35°N in the north.

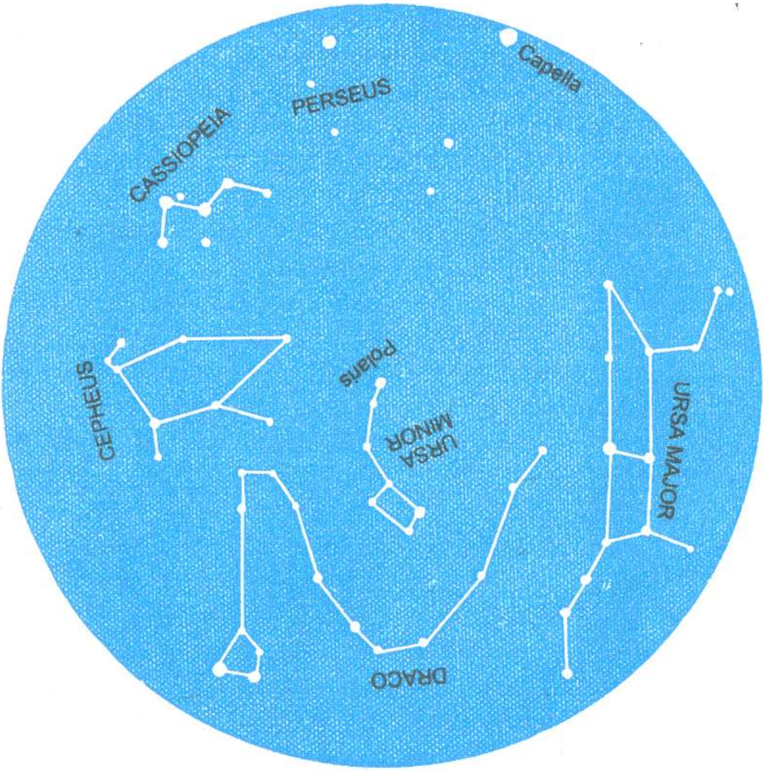
I have used a simple step-by-step approach to enable the reader to first identify and get familiarised with a bright constellation and then move on to others around it. Wherever possible, useful tips are provided to locate a not-so-bright star or constellation in a difficult-to-locate situation. The times at which the prominent constellations and bright stars culminate, that is, appear highest in the sky are also given to enable the reader to get the best view of them. The distances of the constituent stars of the constellations are given to enable the reader to get an idea of the enormous distances that separate the stars of the same constellation in many cases.

Unfortunately, the sky over Indian cities has become so polluted—with smoke and dust from motor vehicles and industry and light from electric illumination—that at times even the brighter stars are difficult to spot, except when there is a black-out due to a power failure! But the sky over the smaller towns and villages and in the hills still remains reasonably free from pollution and offers great scope for starwatching.

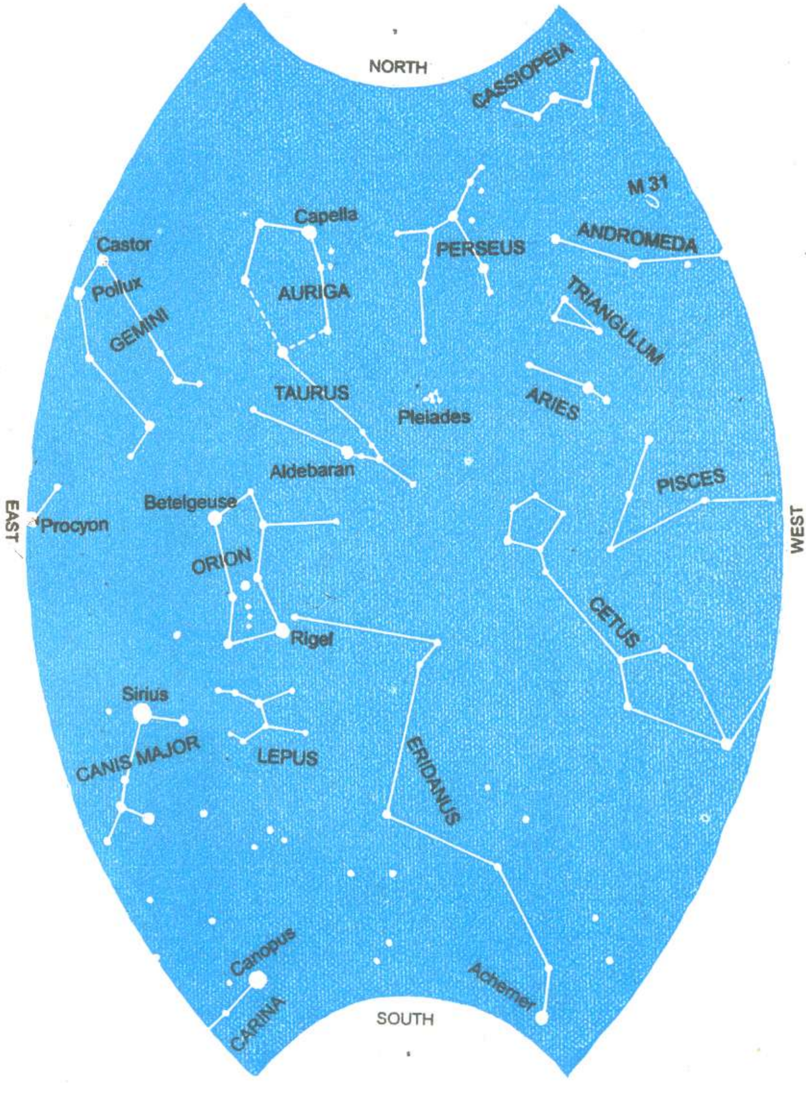
The motivation for writing this book came from many friends and young enthusiasts who evinced keen interest in starwatching after they had a glimpse of the night sky through my telescope. I am particularly indebted to Prof. Yash Pal and Prof. Amalendu Bandyopadhyay for their

valuable suggestions which have helped me a lot in bringing the text into its present form. Of course, the final manuscript may not have seen the light of the day had it not been for the persistent reminders from Ms Manju Gupta of NBT for which I am thankful to her. My task was made easier by Shri C.G. Raphael who keyed in the entire text on computer and made all the necessary changes whenever called for. Finally, I am grateful to my wife Aloka for bearing patiently with me during the long hours I spent at work on the book.

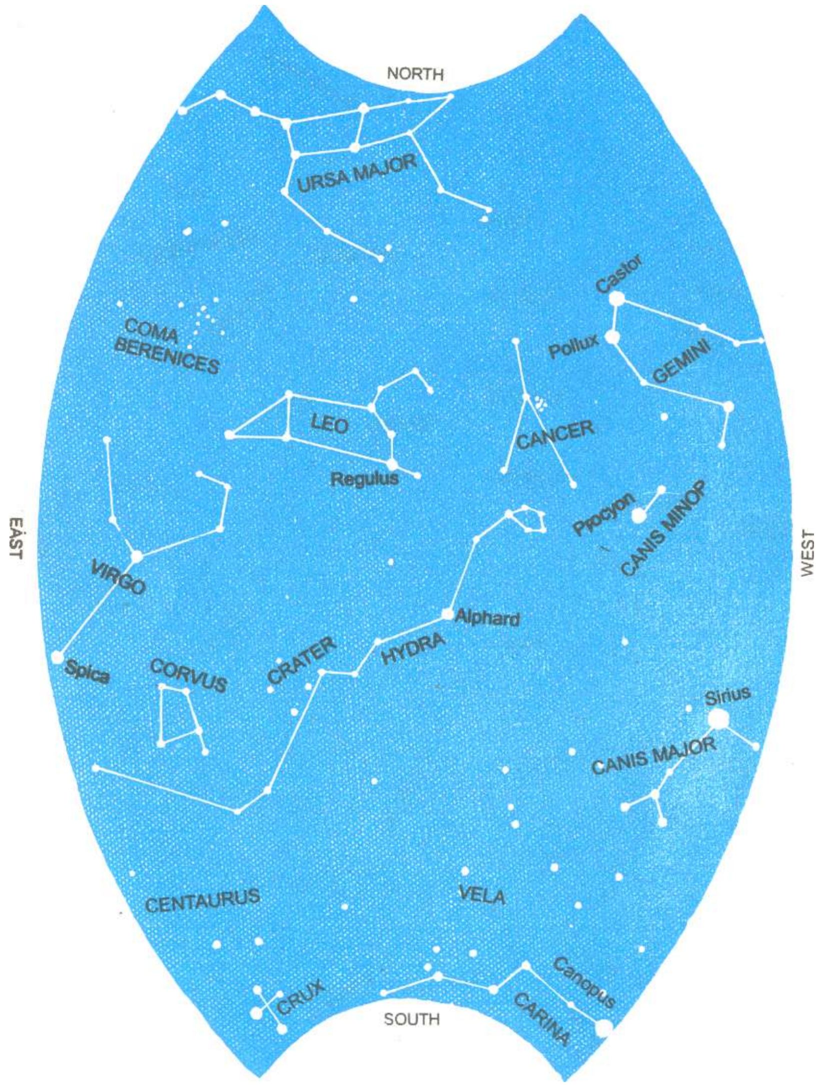
New Delhi
July 1998 BIMAN BASU



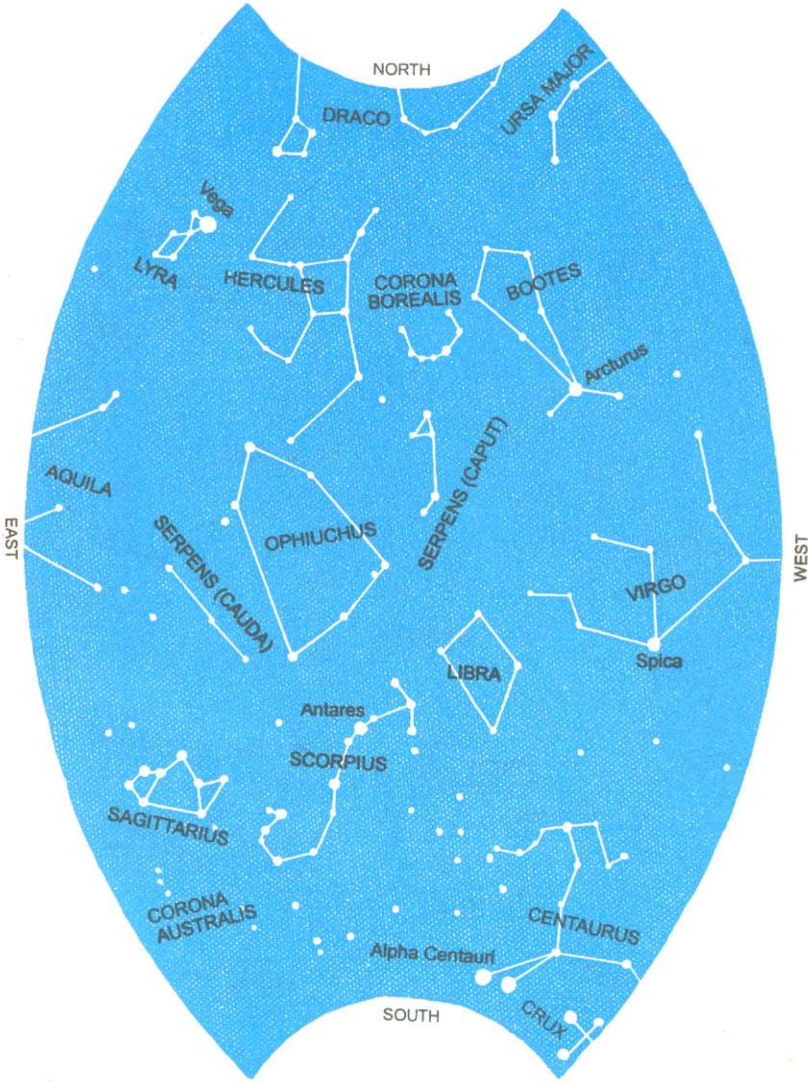
Northern polar constellations.



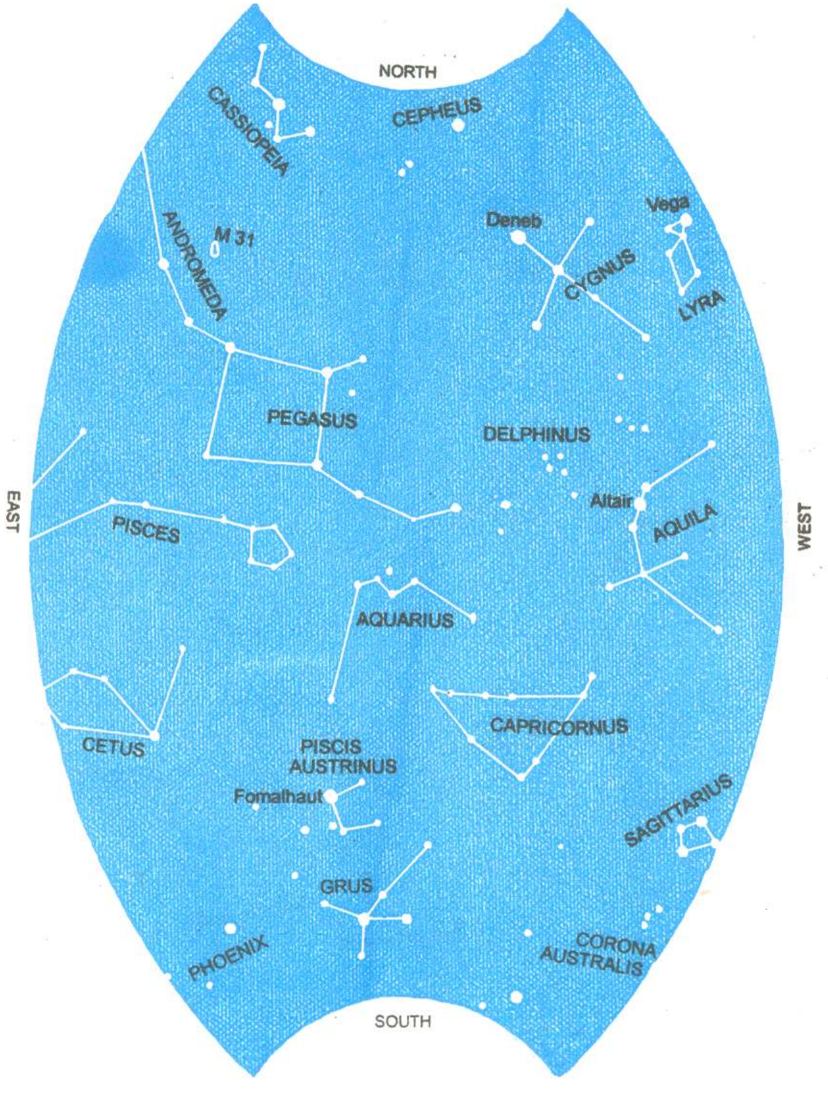
The sky in winter.



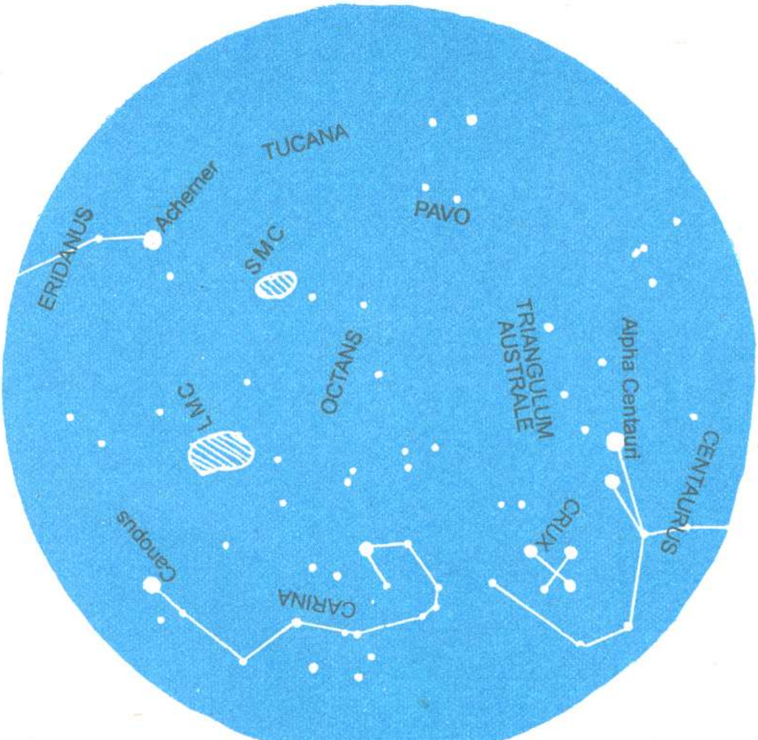
The sky in spring.



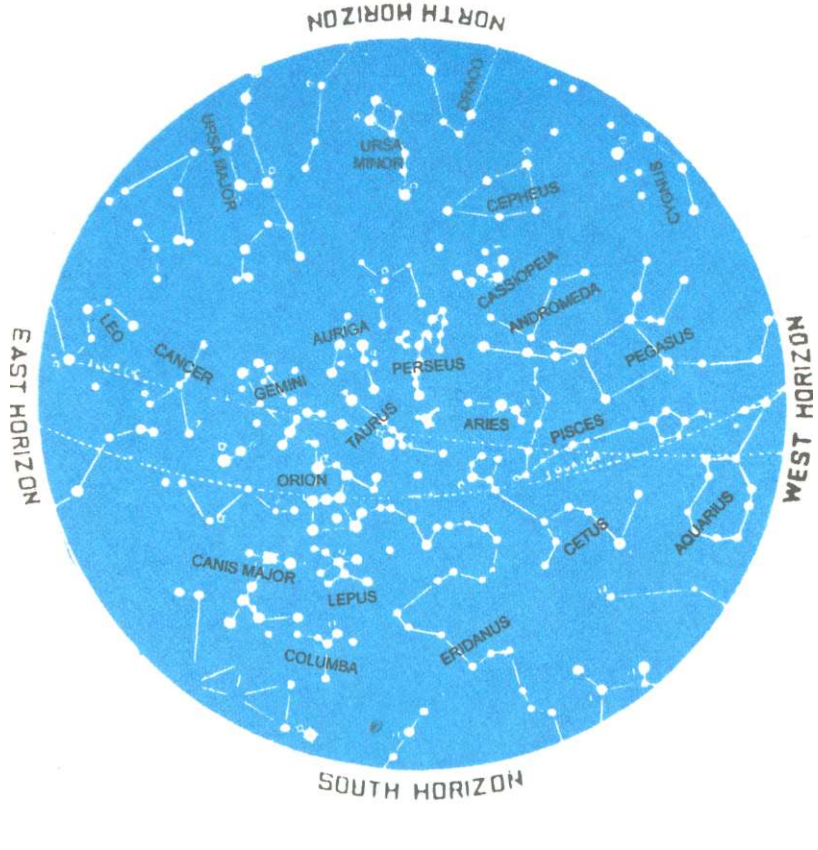
The sky in summer.



The sky in autumn.



Southern polar constellations.



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THE NIGHT SKY

The sky on a clear day is an expanse of monotonous blue, may be with a few whiffs of cloud. But after sundown things change dramatically As daylight fades into dusk and then into night, the beauty of the star-studded sky reveals itself in its full glory. If it is a moonless night and the sky is clear, and if we are far away from city lights, we will be able to appreciate this beauty.

At first we may feel bewildered at the sheer number of stars that we see. We may wonder if we can ever recognise them individually. But we needn't get disheartened. We can learn how to recognise the stars with the help of sky maps and a few tips given in this book.

Almost all newspapers publish a sky map on the first of every month showing the constellations and planets visible during tl <_ month, but these maps are difficult to use unless we know how to use them. This is because, firstly, they try to show on a flat surface what actually is seen as a hemisphere. This greatly distorts the shapes of the constellations and also their relative positions. Secondly, and this is important, these maps are drawn for only a particular hour of the night and can be used only at a particular latitude. Por example, the sky map shown on the opposite page shows the night sky at Delhi (latitude 28° 39'N) at 9 p.m. on January 1, or at 8 p.m. on January 16, or at 7 p.m. on February 1. If we live in a more northernly latitude, in Srinagar (lat. 34°N), for example, then we will

not be able to see the stars near the south horizon shown in the map. On the other hand, a viewer in Kanyakumari (lat. 8°N) will see a completely different sky. From there, the pole star (Polaris) will be seen almost on the northern horizon, while stars and constellations unseen from northern latitudes will become visible.

These difficulties can be overcome to a large extent by sky maps which can be designed for use at any hour at any latitude which undoubtedly will be rather complex. But there is an easier way: to first learn to recognise a few prominent stars and constellations and then use them as pointers to identify others. It is like trying to find an address in a new city. A city map is helpful, but we can also do it by asking the way from the railway station, or bus terminus, using various landmarks such as parks, hotels, markets, post offices, etc. as pointers.

Whether we use the sky maps published in newspapers or those we find in this book, we have to remember one thing: the relative orientations of the cardinal points (north, east, south, west) shown in a sky map are different from those we find in a conventional geographical map. For exan pie, in conventional maps the top usually denotes north, bottom south and the left and right denote west and east respectively. In a sky map it is different because we look *up* at the sky. In fact, the correct way to read a sky map is to hold it overhead and when we do that and look up, we will find if we keep north at the top (actually pointing to our back) then east will be to the left and west to the right, the opposite of what we find in a geographical map.

The constellations in the sky will appear as shown in the sky maps only if we are looking at them facing the right direction. While rising and setting, some of the familiar constellations may appear strange and we may not be able to recognise them till they are well up in the sky. The best way to get familiar with the constellations is therefore to observe them when they are culminating, that is, when

they are at the highest point during their passage across the sky. The time of culmination of most of the important stars and constellations are given in this book.

Of course, before we try to identify the constellations we must get familiar with the directions north, south, east and west. A magnetic compass is handy and will help us in facing the right direction. But it is better try to find some landmarks—a tree, a pole, a chimney or a building—to mark our direction.Once we get familiar with the constellations, the stars themselves will become our direction finder.

How Many Stars?

If we are blessed with a good eyesight we should be able to see about 3,000 stars with unaided eye on a clear moonless night. But usually many of them cannot be seen because they are near the horizon where atmospheric haze blots them out. Glare of city lights obscures some more of them so that a city dweller is able to see only a few hundred stars even under the best viewing conditions.

Wherever we may be, even if we look casually at the night sky we will notice that not all stars are equally bright. Some are so bright that we can see them clearly even under city lights while some are so faint that they are hardly visible. In sky maps these various brightnesses are shown as different 'magnitudes' in the shape of large or small dots. Each step on the magnitude scale represents a factor of 2.5. For example, a star of magnitude 1 is 2.5 times brighter than a star of magnitude 2. Similarly a star of magnitude 1 is 6.25 times brighter than a star of magnitude 3 and so on. (Stars of magnitude one or less and up to magnitude 1.5 are known as first magnitude stars; stars fainter than magnitude 1.5 but brighter than magnitude 2.5 are second magnitude stars, and so on.) We must remember here that the brightness of a star as seen from Earth is only its apparent brightness and depends on both the star's actual or 'absolute' brightness and its distance from Earth. So,

an apparently faint star may be actually very bright but too far distant, and an apparently bright star may not be really very bright but may appear so because it is very close to us.

Stars may even have a negative magnitude. Obviously these would appear even brighter than the first magnitude stars. In all there are about 20 stars of first magnitude or brighter. The brightest of them, Sirius, has a magnitude of -1.46. On clear nights stars of up to magnitude 4 are normally visible in the city sky, but fainter ones (up to magnitude 6) can be seen from the countryside where there is no glare of city lights.

The First Magnitude Stars

Star	*Constellation*	*Magnitude*
Sirius	Canis Major	-1.46
Canopus	Carina	-0.72
Alpha Centauri	Centaurus	-0.27
Arcturus	Bootes	-0.06
Vega	Lyra	+0.03
Capella	Auriga	0.08
Rigel	Orion	0.12
Procyon	Canis Minor	0.38
Betelgeuse	Orion	0.50
Achernar	Eridanus	0.51
Agena	Centaurus	0.68
Altair	Aquila	0.77
Aldebaran	Taurus	0.85
Acrux	Crux	0.87
An tares	Scorpius	0.96
Spica	Virgo	0.98
Fomalhaut	Piscis Austrinus	1.16
Pollux	Gemini	1.20
Deneb	Cygnus	1.25
Regulus	Leo	1.36

Variable Stars

There are also stars the brightness of which varies over a period of time ranging from hours, days or weeks. Such stars are known as variable stars. Many of them make interesting objects for observation. There are basically two kinds of variable stars and their brightness varies due to completely different reasons. One class of variable stars known as Cepheid variables (see page 24) change in brightness due to periodic changes in the size of the star which pulsates regularly every few days or weeks. During this pulsation the radius of the star may change by as much as a few million kilometres. When a Cepheid has contracted to its limit, that is, it has reached its smallest size, the surface temperature is highest and the star reaches its peak brightness. At the other extreme, when the star has expanded to its largest dimensions, its surface cools and it attains its least brightness. Cepheid variables are important because astronomers use them as a standard for measuring distances of stars.

The other type of variable stars are the eclipsing binaries. Such a star is usually made up of two stars close by, one orbiting the other. If one of them is less bright than the other, then, every time the dimmer companion comes in front of the brighter star as seen from Earth, the overall brightness of the two appears to dim. Since the dimming is caused by eclipse of the brighter star by its less bright companion, it is called eclipsing variable (see also page 46).

Another thing we will notice about the stars is that they come in a wide range of colours. Some are bluish-white, some are yellow and still others have a deep orange colour. The colour of a star tells us something about its surface temperature. For example, as the electric element in a toaster or oven heats, the colour changes from a deep red to orange. If the temperature is increased further, it would turn yellow, then white and finally blue (by which time it would have melted). The sequence of the colours in the rainbow is matched in the metal by increasing the heat.

We see the same phenomenon in stars. The reddish-orange stars are the coolest (roughly 3000°C) while the bluish-white stars are the hottest (about 20,000°C). The yellow stars lie somewhere in-between.

The Changing Pattern

If we observe the night sky for a few weeks we will notice that it is constantly changing. The positions of the various constellations and stars as we see them tonight at a particular hour will not be the same at the same time tomorrow. This happens because on any night, at a particular place, the stars and constellations 'rise' about 4 minutes earlier than on the previous night. So the night sky at 9 p.m. on January 1 will be the same as at 8.56 p.m. on January 2, or at 8.52 p.m. on January 3, and so on. On January 16 the same star positions will be seen at 8.00 p.m. and on January 31 at 7.00 p.m. Thus we see that the constellation pattern moves constantly westward. At the end of the year, that is, after 12 months, the sky pattern is again the same as at the beginning.

This apparent westward motion of the constellations is caused by Earth's orbital motion around the Sun. As the Earth goes round the Sun, the stars on the dark (night) side become visible and those on the day side are blotted out by the Sun. The pattern changes progressively the year round.

An implication of all this is that on any particular date, at a particular hour, the position of the constellations in the night sky as seen from a particular place would be the same irrespective of the year. In other words, the pattern of stars in the night sky that we see at 10.00 p.m. on June 1, 1997, for example, is the same as it was on the night of June 1, 1977 and will be on June 1, 2017 at the same time. Only the positions of the planets would change for reasons we shall see later. Of course, the sky pattern does change, but it does so over a period of several thousand years due to the slow wobbling of Earth's axis as it spins like a top.

Timings for Using the same Sky Map on Different Dates

Jan.	1	9.00	p.m.	Jan.	16	8.00	p.m.
Feb.	1	7.00	p.m.	Feb.	16	6.00	p.m.
Mar.	1	5.00	p.m.	Mar.	16	4.00	p.m.
Apr.	1	3.00	p.m.	Apr.	16	2.00	p.m.
May.	1	1.00	p.m.	May.	16	12.00	noon
Jun.	1	11.00	p.m.	Jun.	16	10.00	a.m.
Jul.	1	9.00	a.m.	Jul.	16	8.00	a.m.
Aug.	1	7.00	a.m.	Aug.	16	6.00	a.m.
Sep.	1	5.00	a.m.	Sep.	16	4.00	a.m.
Oct.	1	3.00	a.m.	Oct.	16	2.00	a.m.
Nov.	1	1.00	a.m.	Nov.	16	12.00	midnight
Dec.	1	11.00	p.m.	Dec.	16	10.00	p.m.

But we cannot notice it during our lifetime.

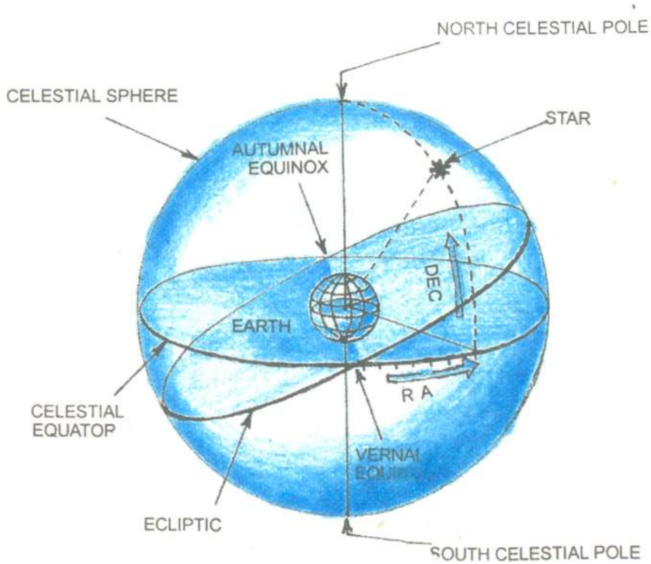
Once we get familiar with the constellations we will be able to use the sky maps published in newspapers and magazines. The map for any month can be used for any other month but at different times and, of course, only during the dark hours. This is specially useful if we want to observe the constellations in the early hours of the morning when visibility is often the best. For example, the sky map shown in the beginning of this chapter can be used on October 1 at 3.00 a.m., on September 16 at 4.00 a.m., on September 1 at 5.00 a.m., or on August 16 at 6.00 a.m. We can work out the early morning timings for other sky maps in a similar way.

GETTING AROUND

The sky as seen from our Earth appears as a hemisphere. If we could see the entire sky at a time, it would appear to us as a globe or sphere seen from inside. In other words, we may think of the Earth as situated within a much larger sphere, the surface of which is the sky. The 'sky' here is, of course, only imaginary because around Earth (and its atmosphere) there is only empty space. And the stars are billions of kilometres away. But if we want to get familiar with the stars, this imaginary sky, or 'celestial sphere' as astronomers call it, offers a convenient framework for locating stars in the night sky.

Coordinates in the Sky

Just as our globe has two poles and an equator, so does the celestial sphere. The celestial north and south poles can be located by extending an imaginary line joining Earth's north and south poles. Similarly if a plane through Earth's equator is extended to cut the celestial sphere, we get the celestial equator. Further, similar to latitudes on Earth (though imaginary), circles can be drawn parallel to the celestial equator on the celestial sphere at regular angular intervals. These celestial latitudes are called 'declination' (Dec.). Declinations north of the equator are assigned positive values (the north pole has a declination of +90°), while those south of it are given negative values (south celestial pole -90°). The celestial coordinate corresponding

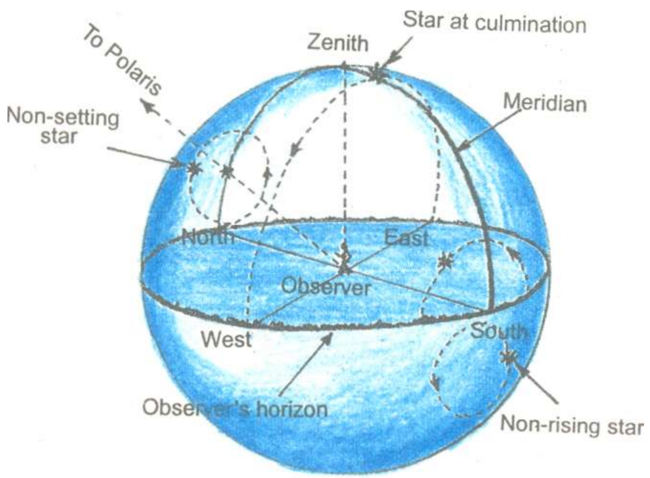


Celestial coordinates.

to longitude on Earth is the 'right ascension' (R.A.) which is expressed in hours, minutes and-seconds of time.

The celestial sphere has on it another feature we do not find on a globe. It is called the 'ecliptic' and charts the positions of the Sun in the sky at different times of the year. As we know, the Earth's axis is inclined at 23 — to the plane of its orbit around the Sun. This makes the ecliptic inclined to the celestial equator at an angle of 23 \ and cut the latter at two diametrically opposite points. These two points are called 'equinoxes' because when the Sun is at any of these two positions, nights and days are of equal length everywhere on Earth. Of the two equinoxes, the Vernal or Spring equinox is also known as the 'First Point of Aries' and corresponds to 0 hour of R.A. (similar to 0° longitude of Greenwich, UK). From this point, the right ascension is measured eastward along the celestial equator.

Yet another reference line on the celestial sphere is the 'celestial meridian' which is the imaginary line joining the north and south celestial poles through the zenith (the



Motions of stars in the sky.

point in the sky directly overhead the observer). The meridian cuts the horizon at exactly the north and south points. Every star appears to cross this imaginary line once daily at the time of culmination when it reaches the highest point above the observer's horizon. The Sun crosses it every day at noon (local time).

Non-setting and Non-rising Stars

As the Earth revolves on its axis from west to east, the celestial sphere appears to rotate in the opposite direction. And so we see the stars rising in the east and setting in the west. But all stars do not follow this routine. To a viewer north of the equator, the pole star (Polaris) in the north (almost coinciding with the north celestial pole) appears

to remain stationary in the sky without ever setting or rising. Other stars appear to move in an anticlockwise direction around it. As a result, depending upon the latitude of the observer, some stars in the northern sky never seem to set while others, in the sourthern sky, never seem to rise at all. From the same latitude, the rest of the stars rise (in the east, northeast or southeast depending upon the declination of the star), culminate, and then set (in the west, northwest or southwest respectively). To an observer in southern latitudes, facing south, the stars appear to move in a clockwise direction around the imaginary south celestial pole. (There is no 'fixed' star corresponding to the south celestial pole in the southern sky.)

If we know the latitude of any place, we can find out which stars are non-setting and which ones are non-rising. New Delhi, for example, has a latitude of 28°N (approx.). If we subtract 28° from 90° we get 62°. This means that from New Delhi, any star with a declination of more than +62° is non-setting. That is, if we look at such a star it would appear to simply go round and round the Polaris without ever dipping below the horizon. Of course, we'll see the non-setting stars only during the night as daylight would blot them out during the day Similarly, all stars with declination less than -62° (in the southern sky) would be non-rising for observers in New Delhi, for they would always lie below the southern horizon.

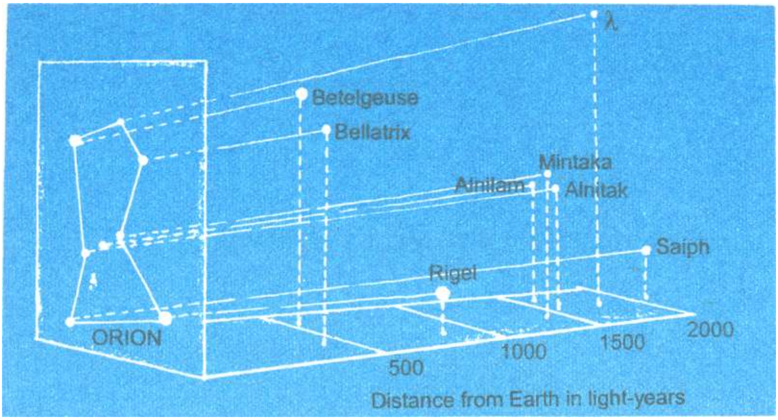
If we are an observer from Kanyakumari (lat. 8°N), the situation would be quite different. From here we will see the Polaris almost on the northern horizon. (In fact, it would be only 8° above the horizon where atmospheric haze almost blots it out.) So, hardly any star in the northern sky would be non-setting from here, and there would be few non-rising stars below the southern horizon. For observers south of the equator, the non-setting stars would be seen in the southern sky and the non-rising stars would be below the northern horizon.

If we are at the equator, all the stars will appear to move overhead, parallel to the east-west direction as they rise and set. But if we happen to be at the north or south pole, the stars would appear to go round in circles around a common centre above our head. The motion will be in a clockwise direction over the south pole and in an anticlockwise direction over the north pole.

THE CONSTELLATIONS

If we are given a map of the world, with only the cities marked (as dots) without names and without any state or national boundary shown, we would surely find it almost impossible to pick out (except a dozen or so, perhaps) any particular city. This is because the state and national boundaries serve as reference points for locating the cities on a map. On the star-filled celestial sphere one cannot draw any boundary or reference line (at best they are only imaginary). But the ancient skywatchers did make out shapes of various things among groups of stars which they called 'constellations'. They named these constellations after mythological gods and heroes, living creatures or common objects. So we have constellations like Orion, Perseus, Andromeda, the Great Bear, the Lion, the Swan, the Scales, the Lyre, and so on.

As we will notice when we get familiar with some of them, the arrangement of stars in a constellation does not always resemble the object it is named after and in most cases there seems to be no logic behind the names. There are, of course, exceptions. The constellations of Scorpius and Leo do indeed resemble a scorpion and a lion respectively. But in most cases, even if we have a great deal of imagination, we will not be able to picture what the name of a constellation, like Aries, for example, calls for. Often, the stars that form the familiar shapes are only a small part of those making up the whole constellation, which



Distances of the stars of Orion.

itself may be quite extensive in size. For example, the seven stars of the Big Dipper in the constellation of Ursa Major constitute only a small part of the bear. Despite these deficiencies, this way of grouping stars does help a lot in identifying and locating them in the night sky.

Another thing we should keep in mind is that the stars that make up a constellation usually have no physical connection between one another, nor are they fixed in space. Although they appear in the same direction in the sky, they are actually at vastly differing distances from us. Some stars may be as much as 10 to 12 times as far away from us as another in the same constellation. They appear as part of the same constellation only because they lie in our line of sight as we look at them from Earth. This is similar to looking at a group of trees from a distance. From far away the trees appear to be arranged in a dense row. But if we go near we find that the trees are scattered randomly with large spaces between them.

So we find that the constellations are neither fixed nor real, but are shapes arising out of our imagination. In fact, we too can imagine any shape by taking a few bright

stars in the sky and joining them by imaginary lines! In reality, however, it is not so. Astronomers have by convention set clear boundaries of the various constellations which are accepted by all. They have grouped all the stars of the sky into 88 constellations. Of course, not all of them will

The Constellations

*Latin Name**	*English/Indian Name*	*Symbol*	*Possessive*
Andromeda	Andromeda	And	Andromde
Antila	The Air Pump	Ant	Antilae
Apus	The Bird of Paradise	Aps	Apodis
Aquarius (Z)	The Water-bearer *(Kumbha)*	Aqr	Aquilae
Aquila	The Egale	Aql	Aquilae
Ara	The Alter	Ara	Arae
Aries (Z)	The Ram *(Mesha)*	Ari	Arietis
Auriga	The Charioteer	Aur	Aurigae
Bootes	The Herdsman	Boo	Bootis
Caelum	Sculptors Tool	Cae	Caeli
Camelopardalis	The Giraffe	Cam	Camelopardalis
Cancer (Z)	The Crab *(Karkata)*	Cnc	Cancri
Canes Venatici	Hunting Dog	CVn	Canum Venaticorum
Canis Major	The Great Dog	CMa	Canis Minoris
Capricornus (Z)	The Sea Goat *(Makara)*	Cap	Capricorny
Carina	The Keel	Car	Carinae
Cassiopeia	Cassiopeia	Cas	Cassiopeiae
Centaurus	The Centaur	Cen	Centauri
Cepheus	Cepheus	Cep	Cephei
Cetus	The Whale	Cet	Ceti
Chamaeieon	The Chamaeieon	Cha	Chamaeleontis
Circinus	The Compasses	Cir	Circini
Columba	The Dove	Col	Columbae
Coma Berenices	Berenices Hair	Com	Comae Berenices
Corona Australis	The Southern Crown	CrA	Coronae Australis
Corona Borealis	The Northern Crown	CrB	Coronae Borealis
Corvus	The Crow	Crv	Corvi
Crater	The Cup	Crt	Crateris
Crux	The Cross	Cru	Cruris
Cygnus	The Swan	Cyg	Cygni
Delphinus	The Dolphin	Del	Delphini
Dorado	The Swordfish	Dor	Doradus
Draco	The Dragon	Dra	Draconis
Equuleus	The Little Horse	Equ	Equulei
Eridanus	The River	Eri	Eridani
Fornax	The Furnace	For	Fornacis
Gemini (Z)	The Twins *(Mithuna)*	Gem	Geminorum
Grus	The Crane	Gru	Gruis
Hercules	Hercules	Her	Herculis
Horologium	The Clock	Hor	Horologii

(Contd. on p. 16)

Hydra	The Sea Serpent	Hya	Hydrae
Hydrus	The Water Snjke	Hyi	Hydri
Indus	The Indian	Ind	Indi
Lacerta	The Lizard	Lac	Lacertae
Leo (Z)	TheLion *(Simha)*	Leo	Leonis
Leo Minor	The Little Lion	LMi	Leonis Minoris
Lepus	The Hare	Lep	Leporis
Libra (Z)	The Scale *(Tula)*	Lib	Librae
Lupus	The Wolf	Lup	Lupi
Lynx	The Lynx	Lyn	Lyncis
Lyra	The Lyre	Lyr	Lyrae
Mensa	The Table	Men	Mensae
Microscopium	The Microscope	Mic	Microscopii
Monoceros	The Unicom	Mon	Monocerotis
Musca	The Fly	Mus	Muscae
Norma	The Rule	Nor	Normae
Octans	The Octant	Oct	Octantis
Ophiuchus	The Serpent Bearer	Oph	Ophiuchi
Orion	The Hunter *(Kaapurusha)*	Ori	Orionis
Pavo	The Peacock	Pav	Pavonis
Pegasus	The Flying Horse	Peg	Pegasi
Perseus	Perseus	Per	Peresei
Phoenix	The Phonenix	Phe	Phoenicis
Pictor	The Painter	Pic	Pictoris
Pisces (Z)	The Fishes *(Meena)*	Psc	Piscium
Piscis Austrinus	The Southern Fish	PsA	Piscis Austrini
Puppis	The Stern	Pup	Puppis
Pyxis	The Mariner's Compass	Pyx	Pyxidis
Reticulum	The Net	Ret	Reticuli
Sagitta	The Arrow	Sge	Sagittae
Sagittarius (Z)	The Archer *(Dhanu)*	Sgr	Sagittarii
Scorpisu (Z)	The Scorpion *(Vrischika)*	Sco	Scorpii
Sculptor	The Scupltor	Scl	Sculptoris
Scutum	The Shield	Scl	Scuti
Serpens	The Serpent	Ser	Serpentis
Sextans	The Sextant	Sex	Sextantis
Taurus (Z)	The Bull *(Vrisha)*	Tau	Tauri
Telescopium	The Telescope	Tel	Telescoppi
Triangulum	The Triangle	Tri	Trianguli
Triangulum Australe	The Southern Triangle	TrA	Trianguli Australis
Tucana	The Toucan	Tuc	Tucanae
Ursa Major	The Great Bear *(Saptarshi)*	UMa	Ursae Majoris
Ursa Minor	The Little Bear	UMi	Ursae Minoris
Vela	The Sails	Vel	Velorum
Virgo (Z)	The Virgin *(Kanya)*	Vir	Virginis
Volans	The Flying Fish	Vol	Volantis
Vulpecula	The Fox	Vel	Vulpeculae

* (Z) indicates zodiacal constellation.

be visible from any one place. Even out of those that are visible from where we live we may not be able to identify all.

Out of the 88 constellations only a small number (about 20) are prominent and can be recognised easily. The rest are made up of mostly faint stars and are difficult to identify. But we can locate many of them by using the prominent constellations as guideposts.

Constellations come in many shapes and sizes. The largest constellation is Hydra, the Water Snake. It is a long and rambling constellation that covers an area of the sky 19 times larger than the smallest constellation Crux, the Southern Cross.

There are different ways of naming the stars. Astronomers designate the bright stars in a constellation by Greek alphabets followed by the Latin possessive of the constellation name. For example, the brightest star in the constellation Ursa Major is named Alpha Ursae Majoris; the brightest star in Scorpius is called Alpha Scorpii, and so on. Many of the prominent stars also have proper names. For example, Alpha Ursae Majoris is also known

Asterisms

Asterism	*Constellation/Stars*
Beehive	Cancer
Big Dipper	Ursa Major
Circlet	Pisces
Hyades	Taurus
Keystone	Hercules
Kids	Auriga
Northern Cross	Cygnus
Pleiades	Taurus
Sickle	Leo
Teapot	Sagittarius
The Pointers	Ursa Major
Summer Triangle	Deneb, Vega, Altair
Winter Triangle	Betelgeuse, Procyon, Sirius

as Dubhe, Alpha Scorpii is called Antares, and so on. Many of the stars have Indian names too, as we will see later.

Many constellations have smaller parts that we can recognise easily and which can help us identify the constellation itself. These smaller groups of stars are called asterisms. One of the most prominent asterisms in the sky is the 'Big Dipper' made up of seven stars of the constellation Ursa f lajor. Others include the 'Northern Cross' of Cygnus, the 'Sickle' of Leo, the 'Teapot' of Sagittarius, the 'Circlet' of Pisces, and the 'Pleiades' of Taurus.

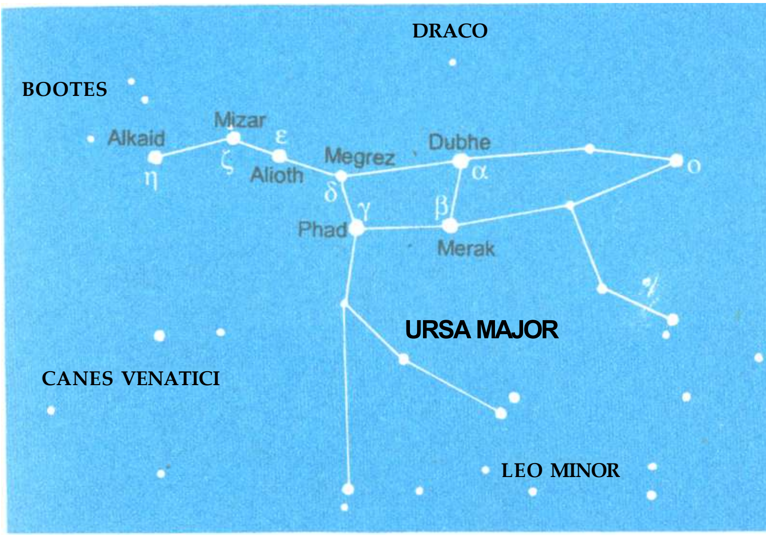
For convenience, astronomers divide the constellations into three broad groups—the northern and southern circumpolar constellations, and the equatorial constellations. Constellations which lie between declinations 40° and 90° north and south of the celestial equator are designated as circumpolar while those lying between declinations -40° and +40° are designated as equatorial.

The Circumpolar Constellations

For the beginner the easiest circumpolar constellation to recognise in the northern sky are Ursa Major or the Great Bear *(Saptarshi)* and Cassiopeia. (The name within brackets is the one by which the star or constellation is known in India.) From higher northern latitudes in Europe, North America and Russia, these two constellations are non-setting and are always seen together on opposite sides of the Polaris *(Dhruvtara).* From north India, they are seen together only during the winter months when Cassiopeia is seen in the northwest and Ursa Major in the northeast. But from down south they are never seen together. From Thiruvananthapuram and Kanyakumari the two are seen only at culmination. At other times they are too near the horizon to be visible.

Ursa Major

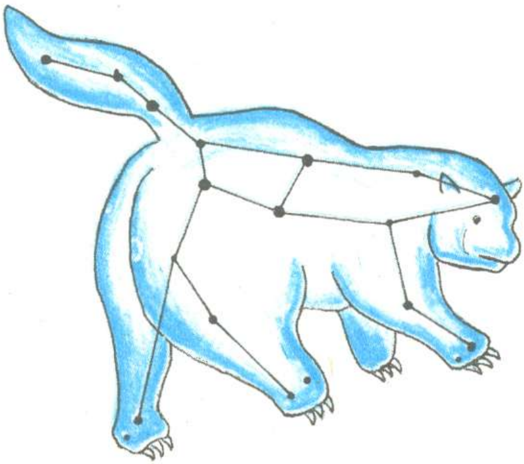
Ursa Major is visible in the night sky from January when



Ursa Major

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Dubhe	1.79	107
P	Merak	2.37	78
y	Phad	2.44	90
5	Megrez	3.31	65
e	Alioth	1.77	68
C	Mizar	2.09	88
Tl	Alkaid	1.86	210

we can see it over the eastern horizon at around 10.00 p.m. In the first week of March it is fully visible in the northern sky. We can easily recognise its familiar pattern of seven bright stars (also known as the Big Dipper), which is only a part of the constellation and is an important 'land-mark' in the sky. The seven stars, starting from the tail, are named Eta Ursae Majoris, or Alkaid (mag. 1.86), Zeta Ursae Majoris, or Mizar (mag. 2.09), Epsilon Ursae Majoris, or Alioth (mag. 1.77), Delta Ursae Majoris, or Megrez (mag.

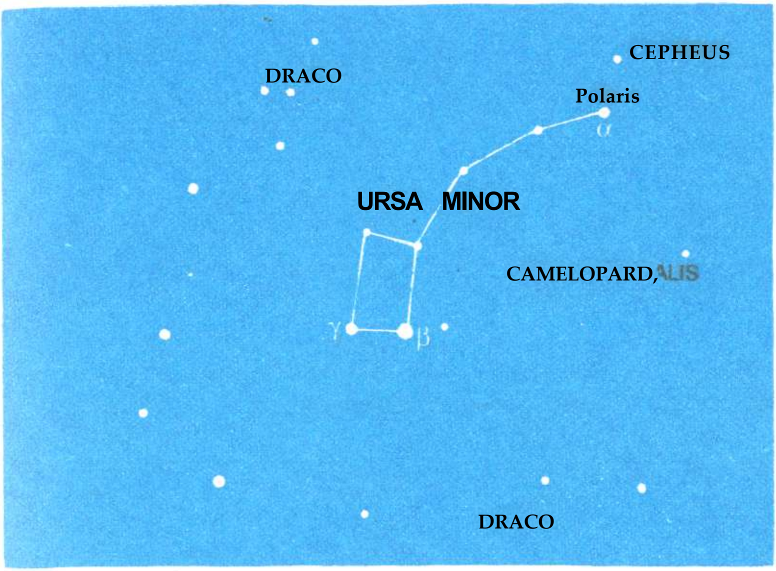


The Great Bear.

3.31), Gamma Ursae Majoris, or Phad (mag. 2.44), Beta Ursae Majoris, or Merak (mag. 2.37), and Alpha Ursae Majoris, or Dubhe (mag. 1.79). The Indian names respectively are *Marichi, Vashistha, Angira, Atri, Pulasta, Pulaha,* and *Kratu.* The star Mizar has a faint companion named Alcor (mag. 4.0), very close to it which is visible to anyone with a good eyesight. The Arabs are said to have used this star as a test of good vision for their soldiers! Ursa Major culminates at around 9.00 p.m. during the third week of April.

Ursa Minor

Merak and Dubhe are also known as the 'pointers' because they show the way to the star Alpha Ursae Minoris or Polaris, the pole star (mag. 1.79). Polaris itself belongs to a much fainter constellation called Ursa Minor or the Little Bear (*Laghu Saptarshi).* Polaris is a supergiant star, 120 times larger than the Sun, lying 472 light-years away. It is a variable star of the Cepheid type and varies in



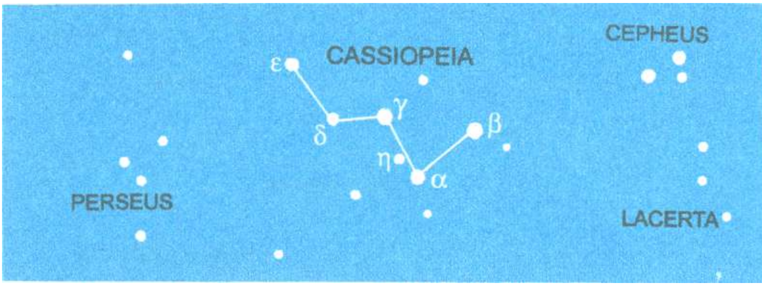
Ursa Minor

Star	Name	Magnitude	Distance (Light-years)
α	Polaris	1.79	472
β	Kochab	2.04	105

magnitude from 1.96 at brightest and 2.05 at dimmest. The seven stars of Ursa Minor, which resembles a smaller version of the Big Dipper, can be seen on a dark moonless night if the sky is very clear. Besides Polaris, the only other bright star in this constellation is Beta Ursae Minoris, or Kochab (mag. 2.04).

Cassiopeia

The other prominent circumpolar constellation in the northern sky, Cassiopeia, is almost directly opposite Ursa Major on the other side of Polaris. It is prominently visible



Cassiopeia

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Shedir	Variable	150
p	Chaph	2.27	45
y	Cih	2.20	96
5	Ruchbah	3.67	43

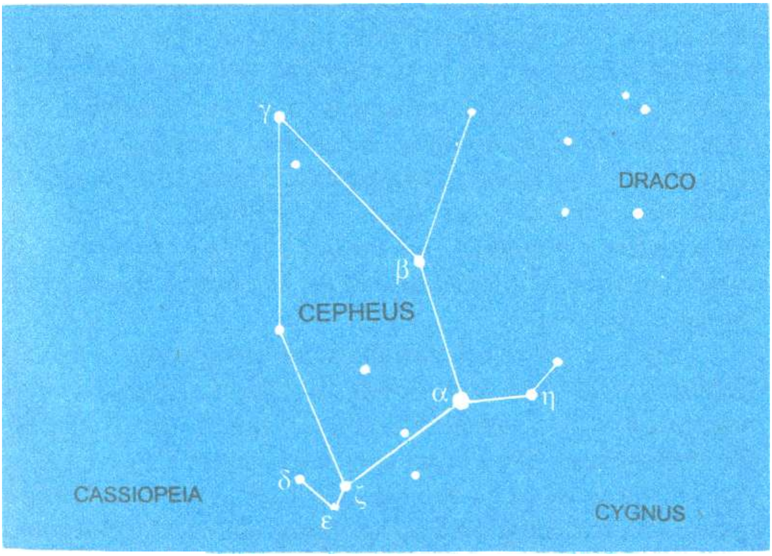
Cassiopeia.

in the evening sky during autumn and winter (from October to February). The constellation has six moderately bright stars forming a distorted 'M' (or 'W')- Four of the stars are brighter than mag. 3. The stars Alpha Cassiopeiae or Shedir, and Gamma Cassiopeiae or Cih are variable stars. The magnitude of Shedir varies between 2.1 and 2.4 while Cih varies between mag. 1.6 and 2.9. As Ursa Major and Cassiopeia are seldom seen together from India, the pointers of the Big Dipper cannot be used to locate the latter. But the M (or W) is so prominent that we will not find it difficult to locate it.

Since the central part of Cassiopeia extends over the Milky Way, we can see a rich collection of stars, star clusters, and nebulas if we look through a pair of binoculars or a small telescope. If we have a telescope with a magnification of 20x or 50x we may be able to spot as many as 20 open clusters in Cassiopeia.

Cepheus

When Cassiopeia is high up in the northeast, if we look



Cepheus

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Alderamin	2.44	46
P	Alphirk	3.23	750
8	–	Variable	1337
e	–	4.20	98
C	–	3.60	717

just west of it we can see a moderately bright star, Alpha Cephei (mag. 2.44) in the constellation of Cepheus, the Sea Monster. We can easily locate it if we extend the line joining the stars Alpha and Beta of Cassiopeia towards west. The constellation of Cepheus is not very prominent because apart from Alpha Cephei, it has no star brighter than the fourth magnitude. But on a clear moonless night we can easily make out the pentagonal shape of the constellation.

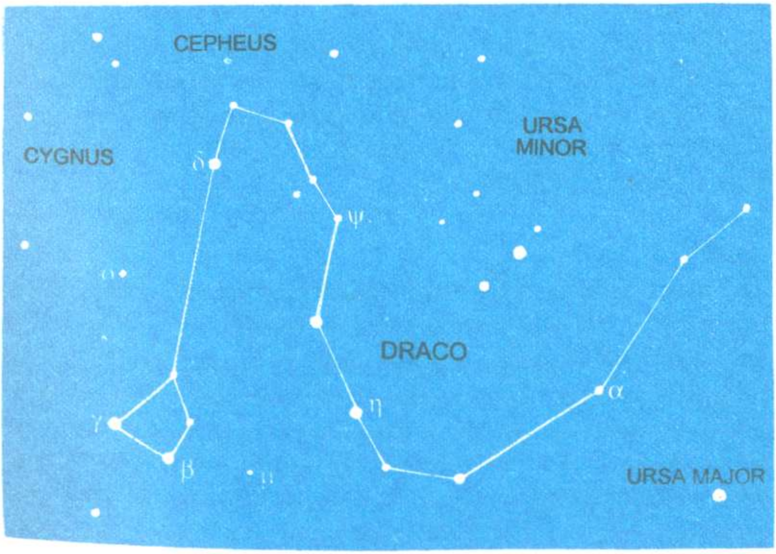
Although it has no bright star, Cepheus has one remarkable star Delta Cephei, which is the first of a kind of variable stars which astronomers use for measuring distances. The regular periodic variation of its brightness was discovered in 1784 by an English amateur astronomer named John Goodricks, who was deaf and dumb but had a keen power of observation. Known as Cepheid variables, the period of variation of brightness of such a star is known to be proportional to its absolute brightness. The brighter the Cepheid variable the longer will be its period of variation, that is, it will take longer to change from dim to bright to dim again.

Like all Cepheid variables, the brightness of Delta Cephei varies with remarkable regularity, changing from magnitude 3.51 to 4.3 every 5 days 9 hours. If we want to see it ourselves there is an easy way. Near Delta Cephei, just to the west of it, we can see two stars Zeta Cephei (mag. 3.6) and Epsilon Cephei (mag. 4.2). The two stars have magnitudes matching the brightness of Delta Cephei

when it is brightest and dimmest respectively. So, when at its brightest Delta Cephei will be as bright as Zeta Cephei and when dimmest it will be dimmer than Zeta Cephei and almost as bright as Epsilon Cephei. It can be real fun watching if we are lucky to have a week or so of clear, dark nights. Cepheus culminates at around 9.00 p.m. during the third week of October.

Draco

Between Cepheus and Ursa Major in the northern sky, we can see the sprawling constellation of Draco, the Dragon. Like Cepheus, this constellation, too, has only one moderately bright star, Gamma Draconis, or Eltamin (mag. 2.2), which marks the head of the dragon. Two other stars—Beta Draconis, or Alwaid (mag. 2.79) and Eta Draconis, or Aldhibain (mag. 2.74)—are also of the third magnitude. The other stars in the constellation are all fainter than the fourth magnitude and can be seen only if the sky is exceptionally clear and dark. Then we can make out a



snake-like shape that surrounds Ursa Minor on three sides. If we have a good pair of binoculars (a 10 x 50 will do), we may be able to see quite a few double stars which include Mu Draconis, Omicron Draconis and Psi Draconis. The star Alpha Draconis, or Thuban (mag. 3.65) was the pole star in ancient times and has moved away from the pole due to the slow wobbling of Earth's axis. Draco culminates at around 9.00 p.m. during the third week of July.

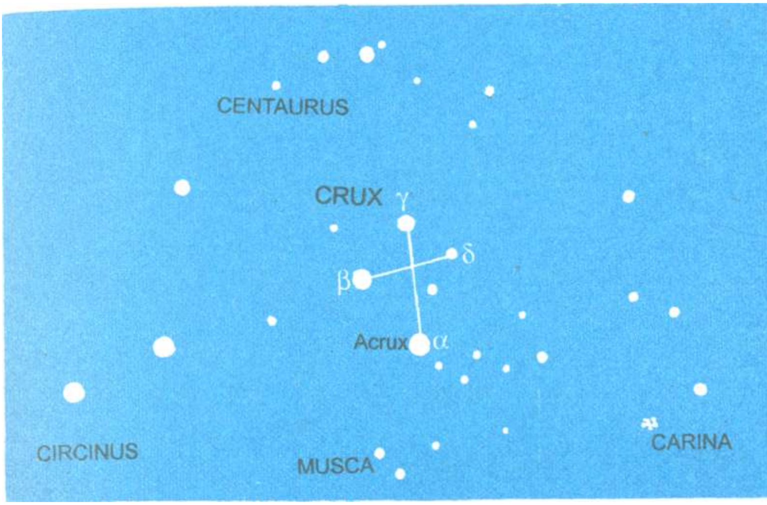
Draco

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Thuban	3.65	232
P	Alwaid	2.79	267
Y	Eltamin	2.20	101
Tl	Aldhibain	2.74	81

Unlike the northern sky, the region around the south celestial pole is almost devoid of bright stars or easily recognisable constellations. The constellation of Octans lies at the pole, but it is made up of mainly faint stars (mag. 6 or more) and is too faint to be visible to the naked eye. In any case, the south celestial pole is not visible from anywhere in India (as it always lies below the horizon) and so need not bother us.

Crux

The most famous of the southern circumpolar constellations is the Crux, the Southern Cross. Although it is a very small constellation (in fact, the smallest) it contains three first magnitude stars and six others of magnitude less than 5. The brightest star of the constellation is Alpha Crucis, or Acrux (mag. 0.87) which forms the southern tip of the cross. Next in brightness are Beta Crucis, or Mimosa (mag 1.28), Gamma Crucis (mag.1.69) and Delta Crucis (mag. 2.81). We can see the Crux over the southern horizon from all



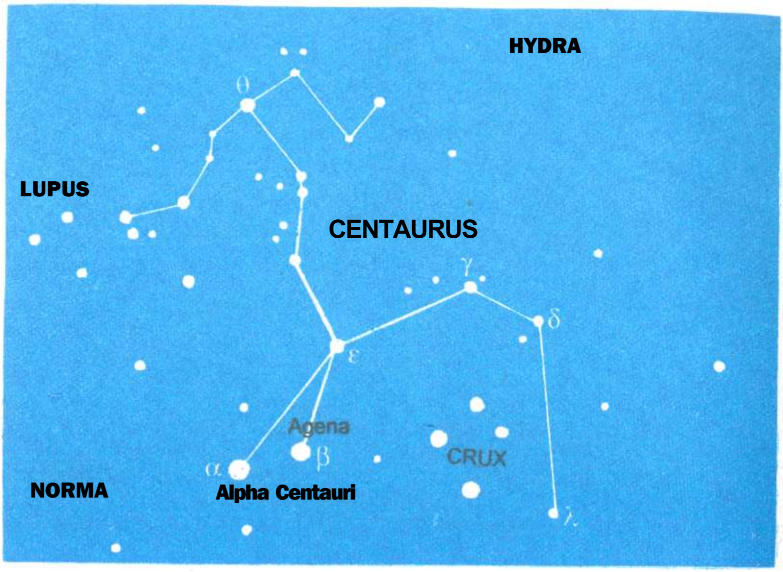
Crux

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Acrux	0.87	370
P	Mimosa	1.28	490
Y	–	1.69	220
5	–	2.81	570

places south of Bhopal (lat. 23°20' N). From Kanyakumari (lat. 8°N) we can see it all through the night for almost two months (from the first week of April to the end of May) when it can be seen to rotate round the imaginary south celestial pole (below the horizon) in a clockwise direction.

Centaurus

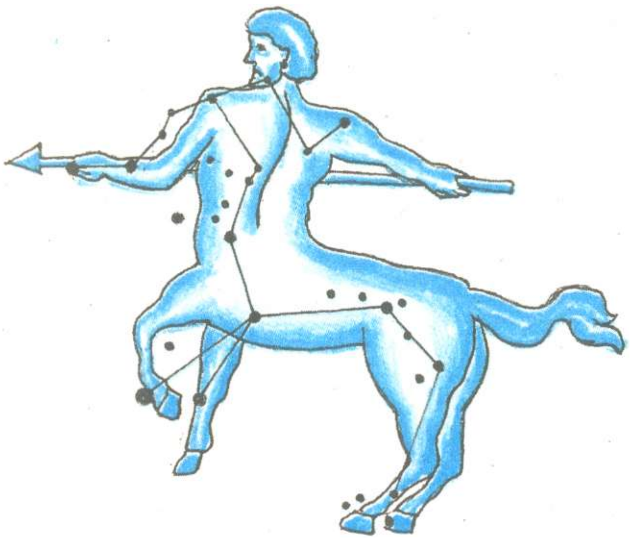
Surrounding the Southern Cross on three sides is the constellation of Centaurus, the Centaur (mythical creature with upper part of a man and lower part of a horse). It has as many as 10 stars brighter than magnitude 3. The



Centaurus

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a		-0.27	4.28
P	Agena	0.63	490
Y	Menkent	2.17	110
5	–	2.60	326

constellation extends from declination -65° to -30°, but its two most bright stars (Alpha and Beta) lie below declination -60° and are visible only from near equatorial latitudes. One of them, Alpha Centauri (mag. -0.27) is of special interest to astronomers. The third brightest star in the sky, it is actually a triple star, made up of two bright stars of magnitudes 0.0 and 1.4, lies at a distance of 4.3 light-years from us. The third star of Alpha Centauri is called Proxima Centauri, which is a faint star (mag. 10.7) and lies at a distance of 4.28 light-years from us. It is the nearest star to Earth (not counting the Sun). The stars Alpha

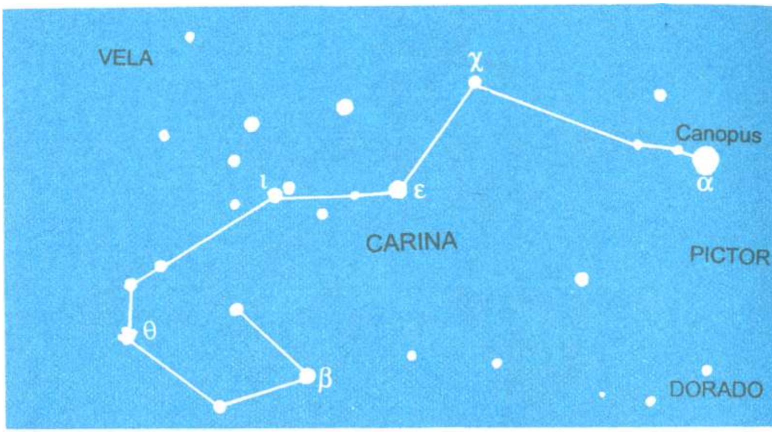


The Centaur.

Centauri and Beta Centauri, or Agena (mag. 0.63) lie to the east of Crux and can be used as pointers to locate the latter. We can see Centaurus from any place south of Bhopal, from April to May all through the night. It culminates at around 9.00 p.m. during the third week of May.

Carina

Another bright star in the southern sky is Alpha Carinae, or Canopus *(Agastya)* in the constellation of Carina, the Keel. It is the second brightest star (mag. -0.72) in the sky and is visible from anywhere in India. If we live in the north we can see it low over the southern horizon during January and February. We can locate it south of Sirius (mag. -1.46), the brightest star in the sky and recognise it easily by its brilliance. Canopus culminates at around 9.00 p.m. during the first week of February.

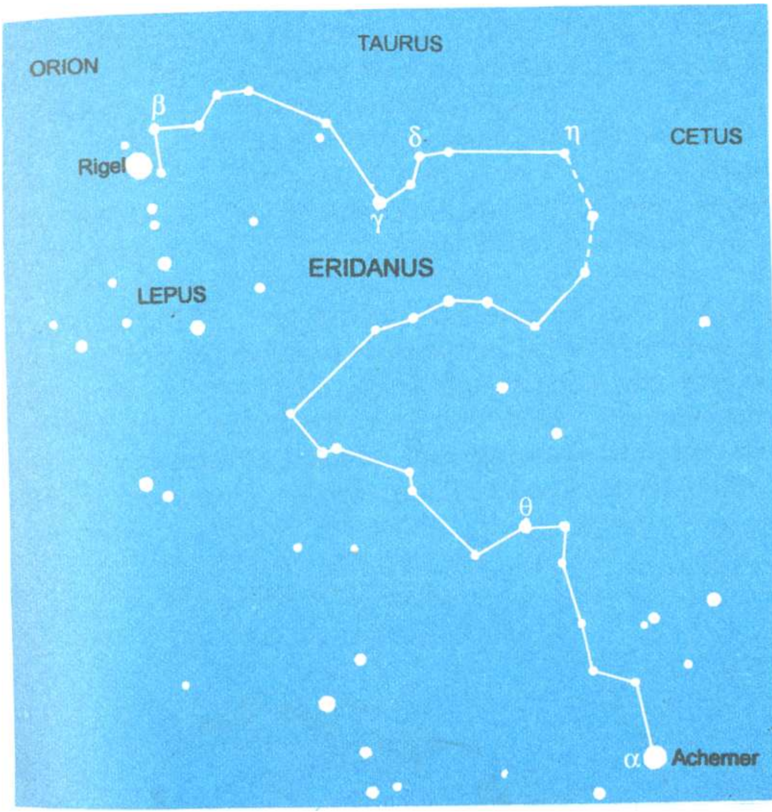


Carina

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Canopus	-0.72	650
|3	Miaplacidus	1.67	86
e	Avior	1.86	340

Eridanus

Eridanus, the River, is a sprawling constellation which is partly equatorial and partly circumpolar. This constellation certainly has the strangest shapes of all. Because it is supposed to resemble a river, the ancient celestial map-makers went out of their way to make it as long as possible. Its brightest star Alpha Eridani or Achernar (mag. 0.46), is so far south in the sky that it is rarely seen from north India. But from all places south of Bhopal we can see it above the southern horizon during November and December. We can locate it easily because of its brightness and the fact that there is no other bright star in the southern sky at that time of the year. Achernar culminates at around 9.00 p.m. during the first week of December. Except for



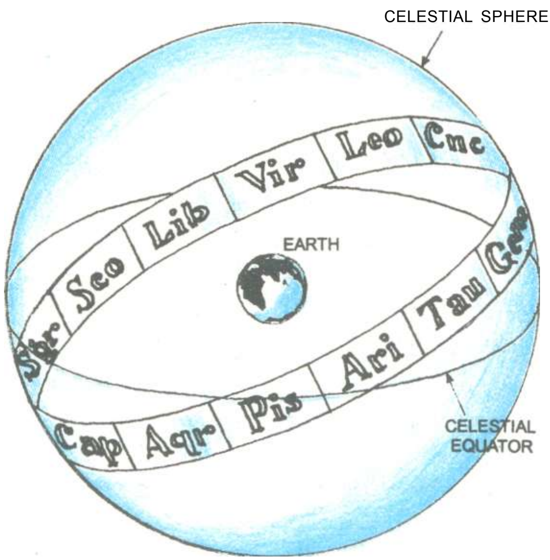
Eridanus

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Achernar	0.51	118
P	Kursa	2.79	80
e	Acamar	2.92	65

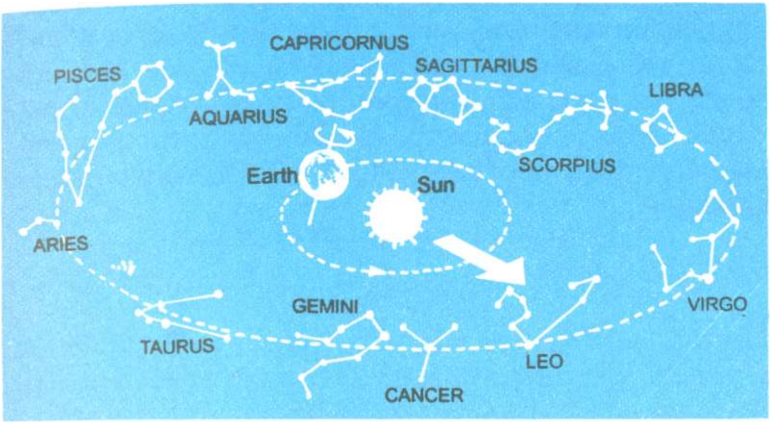
Achernar the constellation has no star brighter than magnitude 3, but it contains some 300 stars visible to the unaided eye. Of course, in the glare of city lights we may be able to see only a few of them.

Equatorial Constellations

Among the important equatorial constellations are the twelve 'zodiacal' constellations that lie on the ecliptic. The Zodiac is an imaginary zone on the celestial sphere, about 8° wide on each side of the ecliptic which forms the background for the motions of the Sun, the Moon and the planets wherever they may be in orbit. The Zodiac is divided into 12 sections, each identified with a constellation called a zodiacal constellation, or *rashi* in Indian astronomy, and represented by a zodiacal sign. (Of course, there is no scientific basis to relate the zodiacal sign, or birth sign, of a person to his or her personality or fortune as is made out by practitioners of astrology.) The twelve zodiacal constellations (*rashis*) are: Aries, the Ram (*Mesha),* Taurus, the Bull (*Vrisha),* Gemini, the Twins (*Mithuna),* Cancer, the Crab (*Karkata),* Leo, the Lion (*Simha),* Virgo, the Virgin



The Zodiac is an imaginary circular band on the celestial sphere divided into 12 parts.



The apparent movement of the Sun through the zodiacal constellations.

(Kanya), **Libra, the Scales** *(Tula),* **Scorpius, the Scorpion** *(Vrishchika),* **Sagittarius, the Archer (***Dhanu),* **Capricorus, the Sea Goat** *(Makara),* **Aquarius, the Water-bearer** *(Kumbha)* **and Pisces, the Fishes (***Meena).*

During its passage along the ecliptic, the Sun appears to move from one zodiacal constellation to the next in course of about a month, transiting through all the 12 of them in

Passage of the Sun through the Zodiac

Constellation	*The Sun Transits*
Aries	April 10 to May 14
Taurus	May 15 to June 20
Gemini	June 21 to July 20
Cancer	July 21 to August 10
Leo	August 11 to September 16
Virgo	September 17 to October 30
Libra	November 1 to November 24
Scorpio	November 25 to December 17
Sagittarius	December 10 to January 19
Capricornus	January 20 to February 16
Aquarius	February 17 to March 11
Pisces	March 12 to April 18

one year. The zodiacal constellations are important because the planets are seen only in the background of these constellations and nowhere else in the sky. So we need not scan the whole sky if we are looking for a planet. Actually the planets never move beyond 8° on either side of the ecliptic. This is because the greatest inclination of any planetary orbit (except that of Pluto) to Earth's orbital plane is about 8°.

2

THE SKY IN WINTER
(December, January, February)

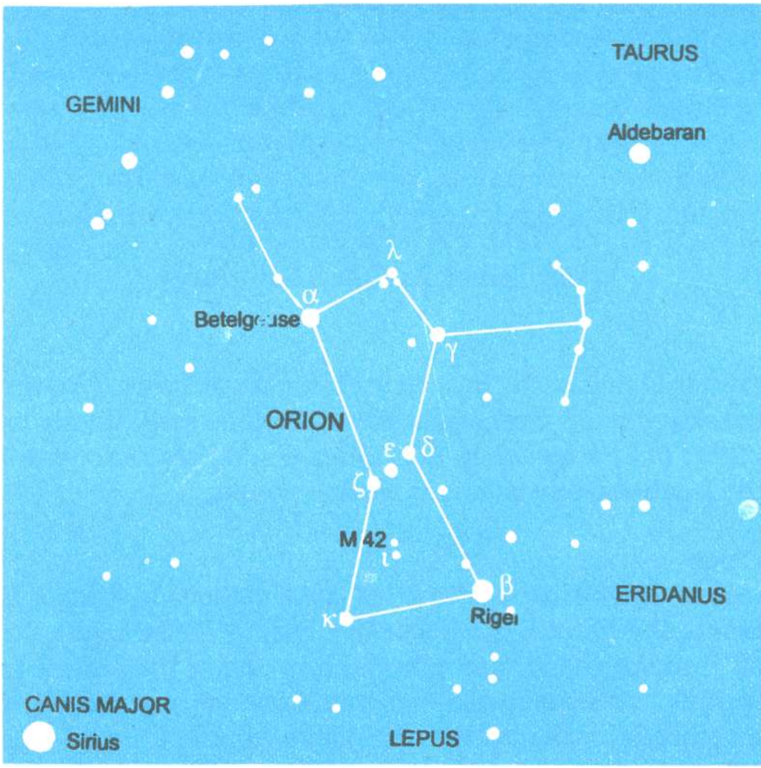
Winter is one of the best times for starwatching. Usually the sky remains clear and it gets dark quite early, giving us plenty of time for observation. Besides, we can see some of the brightest constellations during winter.

Orion

One of the most splendid of all constellations in the sky is Orion, the Hunter (*Kaalpurusha).* Visible in the night sky all through the winter months, it is one of the easiest to identify. Its seven main stars, two of which are of the first magnitude, make up the distinctive figure of a man (the Hunter) wielding a club in his right hand and a shield in his left hand. He has a sword hanging from his belt.

The brilliant orange-red star (mag. 0.5) we see on the Hunter's right shoulder is a red supergiant with a diameter between 300 and 400 times that of the Sun. It is called Alpha Orionis, or Betelgeuse (*Ardra*). Actually, the brightness of Betelgeuse varies over time although we will notice the change only over a period of almost six years. At its brightest (mag. 0.1) Betelgeuse is a little brighter than Aldebaran, the orange star in the neighbouring constellation of Taurus (see p.42). At its faintest (mag. 0.9) !t is dimmer than Rigel, the bright blue-white star that marks the left leg of the Hunter. *Ardra* is one of the 27 *nakshatras* of Indian astronomy (see p.115).

R1gel *(Baanraj)* (mag. 0.12), also known as Beta



Orion

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Betelgeuse	0.50	520
P	Rigel	0.12	900
y	Bellatrix	1.70	470
5	Mintaka	2.50	1500
e	Alnilam	1.80	1600
c	Alnitak	2.10	1600
K	Saiph	2.06	2120
V	Hatysa	2.76	1900

Orionis, is a true celestial searchlight. It is not so large as

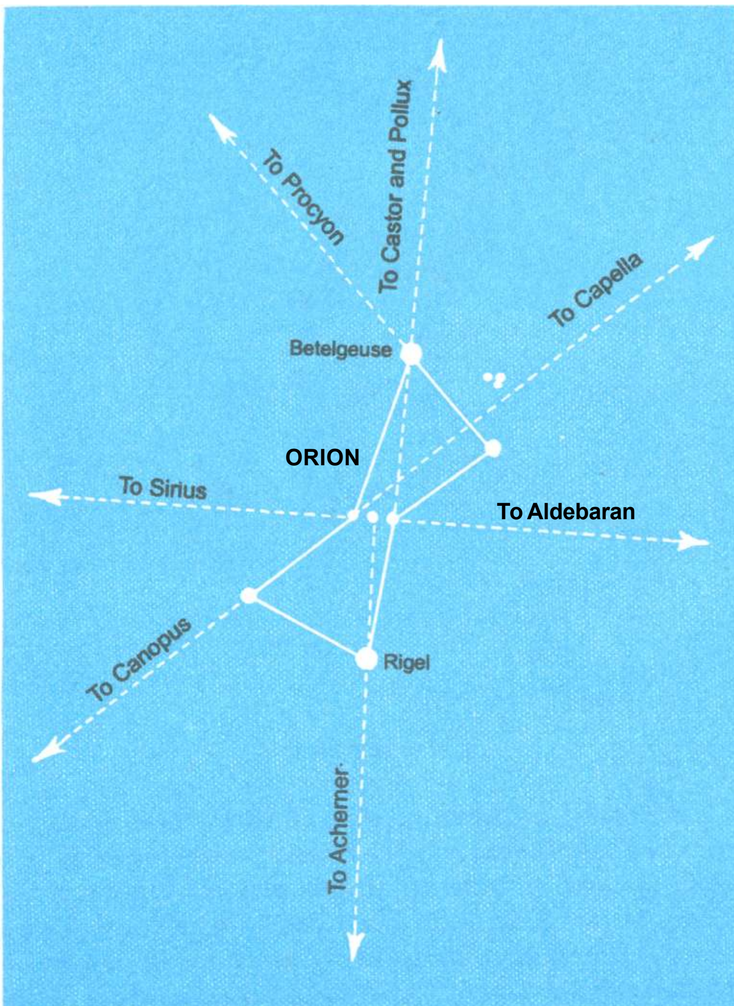
Betelgeuse, but shines with a brightness of about 60,000 Suns. The belt of the Hunter is formed by three bright stars of the second magnitude, all in a single row. The star on the right end of the belt (Delta Orionis) is almost right on the celestial equator; it rises exactly in the east and sets exactly in the west.

The Hunter.

Another interesting star of the constellation is Lambda Orionis (mag. 3.5) which marks the Hunter's 'head'. Known in India as *Mrigasiras,*it is also one of the 27 *nakshatras.* Situated about 1800 light-years away, Lambda Orionis is 9000 times brighter than the Sun and is one of the hottest stars. Its surface temperature is about 35000°C compared to the Sun's 6000°C.

One of the most interesting objects in the constellation

of Orion is the great Orion Nebula (M42) which we can easily spot as a hazy glowing patch in the Hunter's sword. If we look through a pair of binoculars or a low-power telescope we can have a breathtaking view of the nebula



The stars of Orion as 'pointers'.

which appears light greenish in colour. But photographs taken with large telescopes show that its true colour is reddish orange. The nebula was discovered in 1610 by an otherwise obscure astronomer named Peiresec, but its nature was not then realised. We now know it to be a huge cloud of dust and gas, lying at a distance of some 1500 light-years. The nebula is a cloud of hot gas and dust inside which new stars are being born. The cloud glows in the light of the newborn stars.

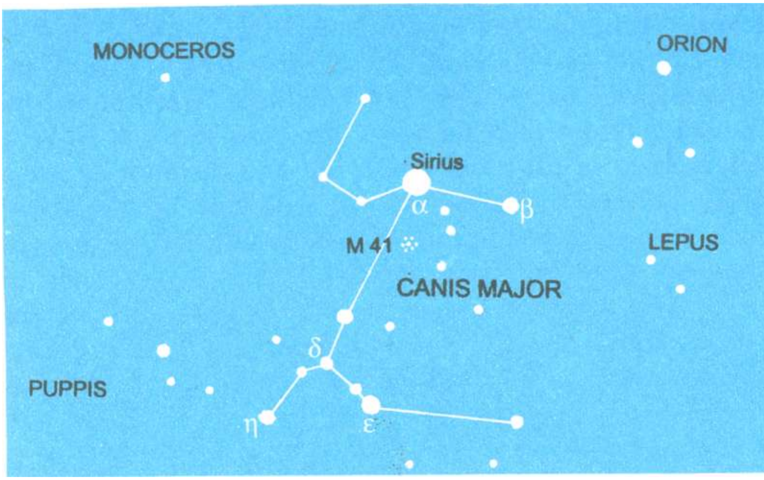
As a direction indicator Orion is unrivalled. Once we are familiar with its stars we can use them to locate several other constellations. There is an old star recognition rhyme which goes like this:

Orion's belt from Taurus's eye
Leads down to Sirius bright;
His spreading shoulders guide we east
Above Procyon's pleasing light.

In early December, Orion rises at around 7.00 p.m. and is a beautiful sight around midnight when it is almost on the meridian in the south. From the first week of January it rises early in the evenings and is visible through the entire night. It culminates at around 9.00 p.m. during the last week of January

Canis Major

If we extend the line of Orion's belt to southeast we will come to a bright white star Alpha Canis Majoris, or Sirius *(Lubdhaka)* in the constellation of Canis Major, the Great Dog. With a magnitude of -1.46, Sirius is the brightest star in the sky. Sirius is also known as the 'Dog Star' and the term 'dog days' of hot summer is associated with it. At one time in ancient Egypt, during the days close to the summer solstice, Sirius appeared in the morning sky just before sunrise. The event was of great importance for the

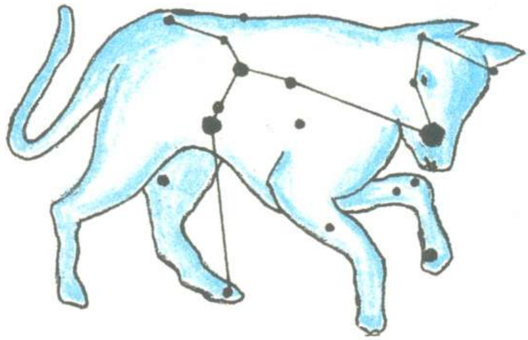


Canis Major

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Sirius	-1.46	8.7
P	Mirzam	2.00	750
5	Wezea	1.86	3100
e	Adhara	1.60	500
n	Aludra	2.40	2500

Egyptians for it marked the time of the annual floods in the Nile river that was so vital for Egypt's agriculture. Situated at a distance of 8.7 light-years, Sirius is one of the closest stars to the Sun. Although Sirius is 26 times brighter than the Sun, it appears exceptionally bright because of its nearness and not because of its inherent brilliance. Sirius culminates at around 9.00 p.m. during the second week of February.

Sirius has a tiny companion called the 'Pup' which only 1/10,000th as bright as Sirius and is not visible except through very powerful telescopes. The Pup is a unique kind of star. Known as a white dwarf it is tiny yet extremely



The Great Dog.

heavy for its size. The Pup is only about 42,000 km in diameter, yet it is as heavy as the Sun.

Apart from Sirius, the constellation has four stars brighter than the second magnitude which we can spot easily. Three of them form a triangle.

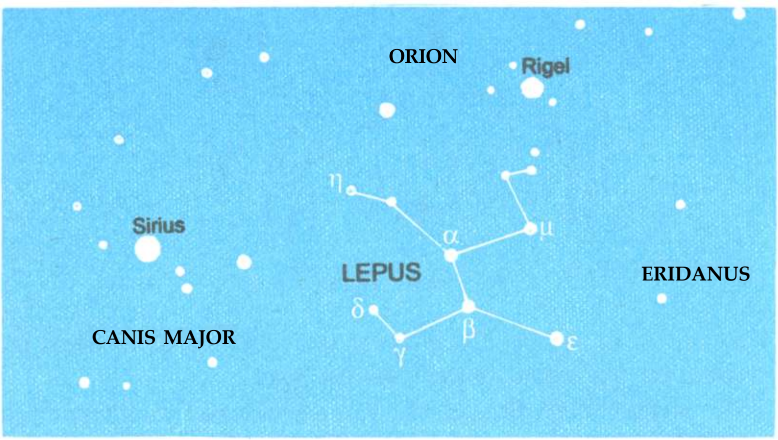
South of Sirius, almost over the horizon from northern parts of India we can spot another bright star Canopus in the constellation of Carina. From southern parts of India Canopus can be seen quite high up in the southern sky in February (see also p. 29).

Lepus

Lepus, the Hare, is a small constellation lying immediately to the south of Orion. It is not a very prominent constellation and has few objects of interest to the amateur star watcher. But there is an old rhyme that gives its direction as follows:

> Orion's image on the south
> Has four stars—small but fair;
> Their figure quadrilateral
> Points out the timid Hare.

The constellation has a variable star R which ranges in brightness from magnitude 5.5 to 10.7 within a period



Lepus

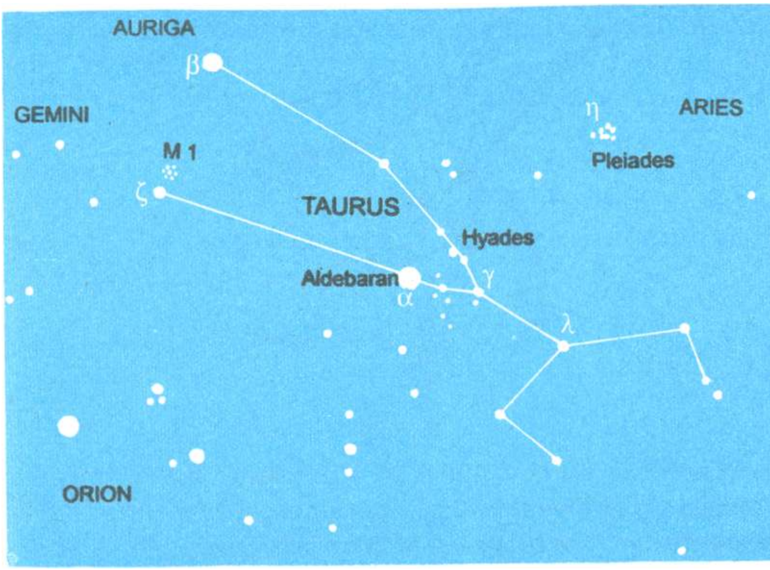
Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Arneb	2.58	945
P	Nihal	2.84	320

about 430 days. We can best see it with a pair of binoculars or a telescope of low power. Because of its intense red colour it is also known as the 'Crimson Star'.

Taurus

Facing south, if we look at Orion we can see one of the most interesting zodiacal constellations to its top right. It is the constellation of Taurus, the Bull (*Vrisha).* We can spot it easily by its leading star, the yellow-orange Alpha Tauri, or Aldebaran (*Rohini)* which we can locate using the stars on the belt of Orion as pointers. It has a magnitude of 0.85. *Rohini* is one of the 27 *nakshatras* of Indian astronomy. It is a red giant, about 100 times as large as our Sun.

As a constellation, Taurus is not very big but it has



Taurus

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Aldebaran	0.85	69
P	A1 Nath	1.65	130
11	Alcyone	2.87	238
y	Hyadum Primus	3.63	166
C	Alheka	3.00	489

1

two of the most remarkable open star clusters visible to the unaided eye. The two clusters are known as the Hyades and the Pleiades *(Krittika).* **We can spot the Hyades immediately to the west of Aldebaran. The stars of the cluster form a rough shape of 'V' with Aldebaran at one tip which can be easily recognised.**

The cluster of Pleiades, also known as the 'Seven Sisters', is much smaller than the Hyades but is much more beautiful. If the sky is not very clear it appears as a

The Bull.

hazy patch to the northwest of Aldebaran. But on a clear, moonless night we can easily make out the individual stars in the cluster. The brightest of them is Eta Tauri, or Alcyone (mag. 2.86). The Pleiades serves as a good test for eyesight.

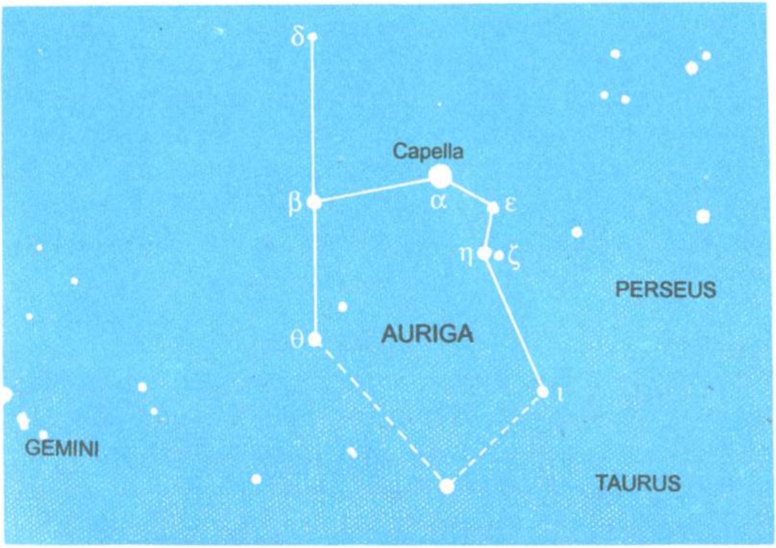
Most people are able to make out only six stars in the cluster with unaided eye. If we have a very good eyesight we may be able to distinguish seven. But under exceptional conditions some observers have been able to spot as many as ten individual stars in the cluster. If we look through a good pair of binoculars we may be able to count as many as a hundred or more! It is really an unforgettable sight. *Krittika* is one of the 27 *nakshatras* of Indian astronomy, and the Indian month of *Kartik* owes its name to this cluster, because during this month, the Moon attains fullness in the vicinity of this cluster. The Pleiades culminates at around 9.00 p.m. during the second week of Tanuary and is followed almost a hour later by Aldebaran.

The constellation of Taurus contains the famous Crab Nebula (Ml) which gets its name from its appearance in photographs taken with powerful telescopes. It lies near the star Zeta Tauri (mag. 3.07) but is a difficult object to locate. We can see it through a pair of good binoculars on a dark, clear night. But then, too, it would appear as a

minute luminous patch. The Crab Nebula is of special interest to astronomers because it is the remnant of a star that exploded as a supernova in A.D. 1054 and is one of the most powerful sources of radio waves in the sky.

Auriga

Another prominent constellation in the winter sky is Auriga, the Charioteer. We can see it just north of Taurus



and locate it easily by its brilliant yellow first-magnitude star Alpha Aurigae, or Capeila (mag. 0.1), the sixth brightest star in the sky. Situated 42 light-years away, Capeila closely resembles the Sun in its physical structure.

The constellation has a distinctive outline—a pentagon formed by five bright stars—which can be recognised without difficulty. The lowermost star of the pentagon, called El Nath (mag. 1.65) was earlier included in Auriga but is now considered part of the constellation of Taurus (Beta Tauri). If we look carefully we can see a

Auriga

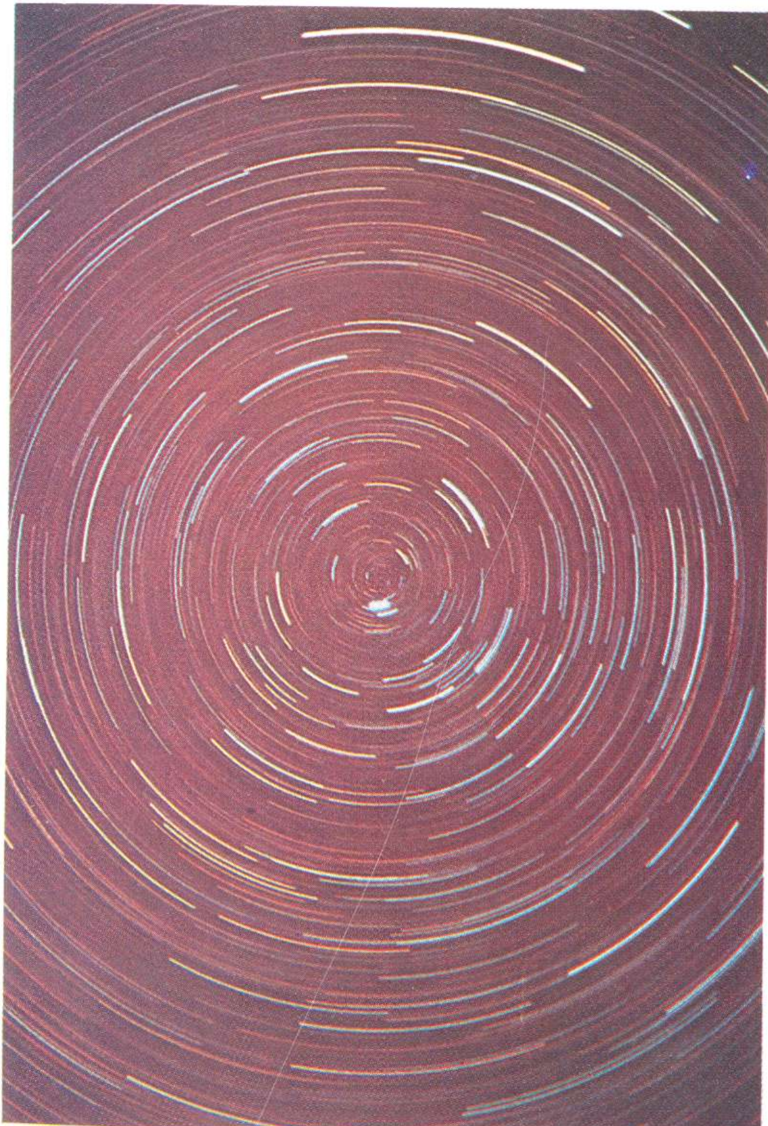
Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	**Capeila**	**0.08**	**42**
P	**Menkarlina**	**1.90**	**72**
8	–	**2.62**	**82**
i	**Hassaleh**	**2.69**	**267**
£	–	**2.99**	**4564**
n	–	**3.17**	**199**

small triangle formed by three faint stars close to Capeila. It is called the 'Kids' and its stars are of special interest to astronomers. Of the three stars the one nearest to Capeila, known as Epsilon Aurigae, is a binary star, the fainter component of which is one of the largest stars known to us. It has a diameter of about 5,700,000,000 km! Auriga culminates at around 9.00 p.m. during the last week of January.

Perseus

Immediately to the west of Auriga is another interesting constellation, Perseus. It contains no first-magnitude star but has an interesting binary star which can be fun to observe, and numerous star clusters. The brightest star in the constellation is Alpha Persei, or Mirphak (mag. 1.8), which is at a distance of about 190 light-years from us. It lies within a scattered cluster of fainter stars which is fun watching through a pair of binoculars. We can easily locate it by extending the line joining the two northern stars of Pegasus (see page 85) and the three principal stars of Andromeda eastward.

The star Beta Persei, which we can see soutn of Mirphak, is one of the most fascinating star** in the sky. It is also known as Algol, which means the 'Winking Demon', for its periodic change in brightness. It is one of those stars astronomers call 'eclipsing variables'. For two days and

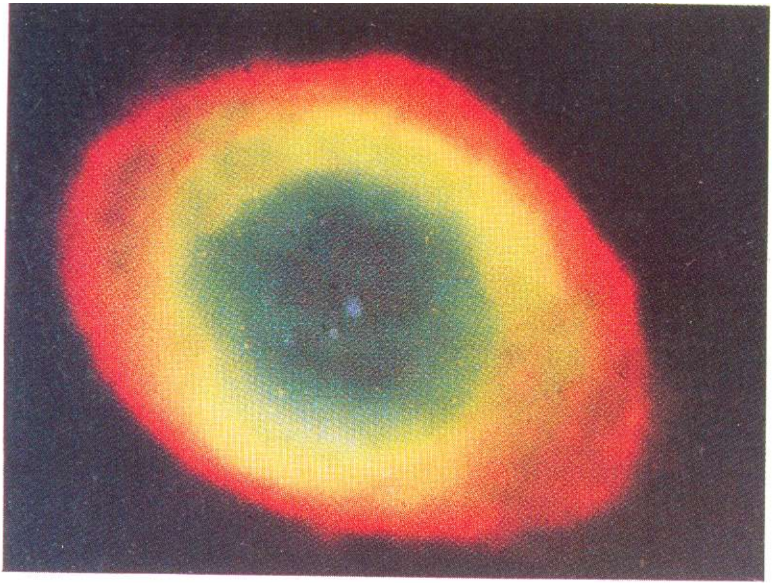


Time exposure showing trails of circumpolar stars.

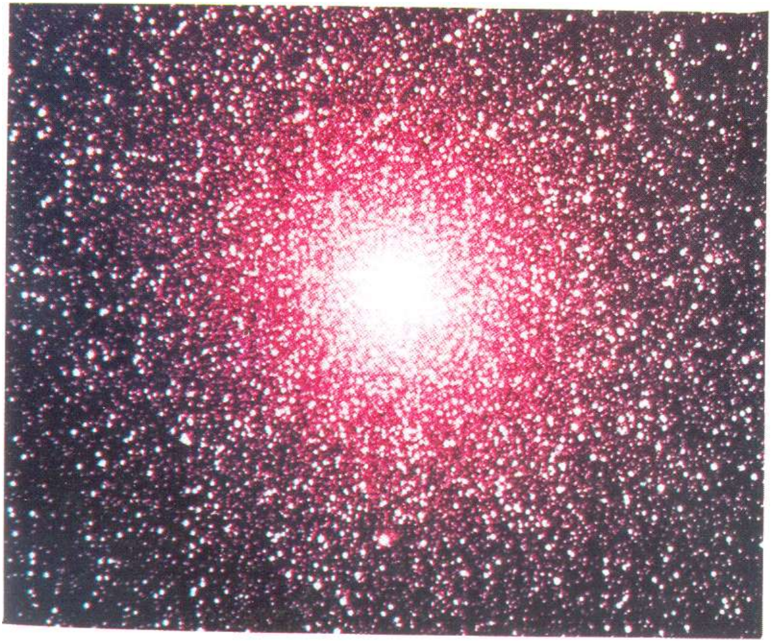
Orion Nebula (M42).

The stars of the Pleiades cluster.

Crab Nebula (Ml) in Taurus.



Ring Nebula (M57) in Lyra.



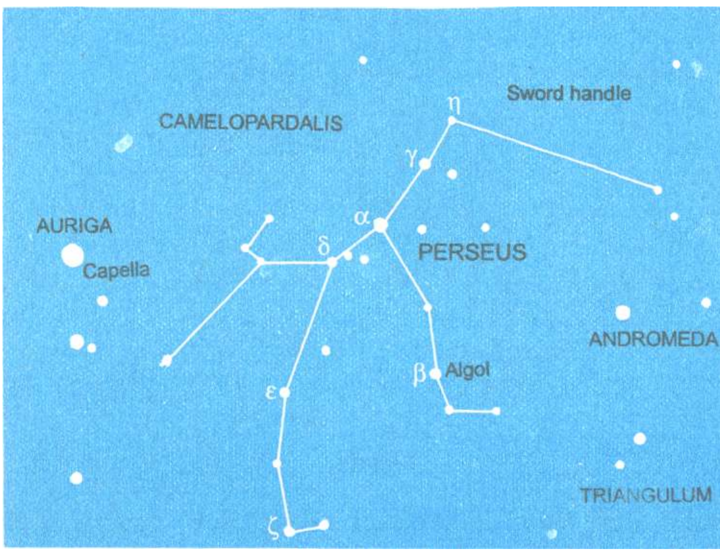
Globular cluster (M13) in Hercules.

North America Nebula in Cygnus.

Andromeda Galaxy (M31).

The Milky Way.

eleven hours, Algol shines steadily as an ordinary star of magnitude 2.3. Then in a period of about four hours, it gets fainter to magnitude 3.5. After remaining dim for only 20 minutes, it brightens up again to its original brilliance



Perseus

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Mirphak	1.80	620
P	Algol	2.3-3.5	95
y	–	2.93	143
C	Atik	2.85	1011
e	–	2.89	678
5	–	3.01	326

in about four hours, and the cycle continues. If the sky is absolutely clear, we may be lucky to observe both the dimming and brighten?ng phases in a single night (as winter nights are pretty long) and it is a thrilling experience. Algol winks' because it is actually made up of two stars revolving

Perseus.

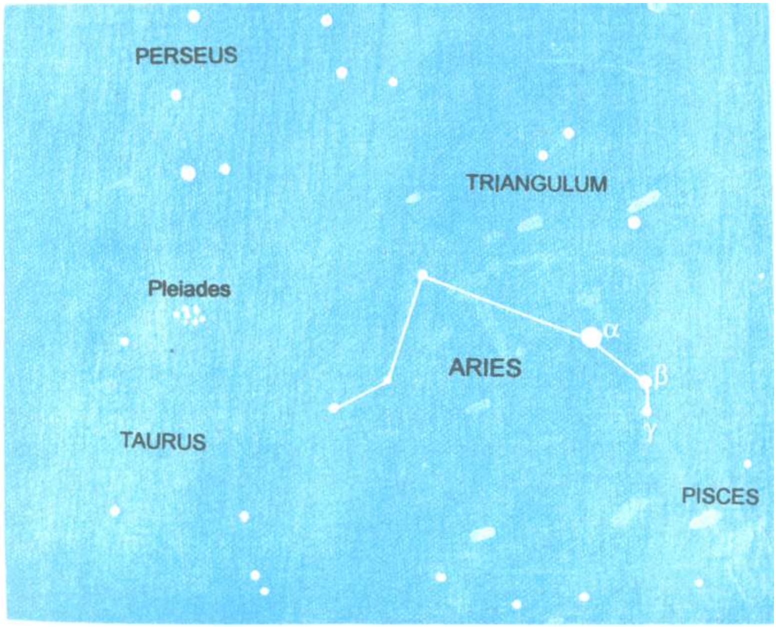
around each other, one of them being much brighter than the other. When the fainter star comes between us and the brighter star, Algol seems to be dimmed. As it moves away, Algol brightens up again.

Among the other interesting objects in Perseus are numerous star clusters, as many as 11 of which can be seen with any medium-power telescope. This is not surprising, as the Milky Way forms the background for most of the constellation. Two of the clusters, named NGC 859 and NGC 884, are quite bright and are visible to the unaided eye on dark nights, appearing as faint symmetrical spots lying between the constellation of Cassiopeia and the star Mirphak. The two clusters form the 'Sword Handle' of Perseus and can be seen separately wi±h a pair of good binoculars or a medium-power telescope. Each of the two clusters contains more than 300 stars. For viewers in southern parts of India, however,

these two clusters will be difficult objects to see as they are too far north in the sky. Perseus culminates at around 9.00 p.m. during the last week of December.

Aries

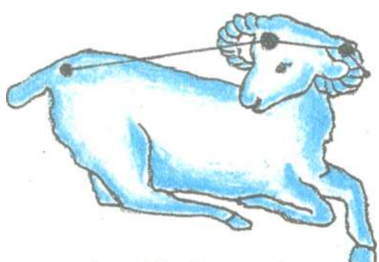
To the south of Perseus and west of the Pleiades lies the zodiacal constellation of Aries, the Ram *(Mesha).* We can spot it by its two moderately bright stars having magnitudes of 2.2 and 2.7. The brighter of the two, Alpha Arietis, is named Hamal (Arabic for sheep) and the other, Beta Arietis, is called Sheratan. Sheratan is identified with *Ashwini,* one of the 27 *nakshatras* of Indian astronomy. The month of *Ashwin* is named after this star as during this month the Moon attains fullness in its vicinity. The constellation has no significant object of interest but its importance lies in its position on the Zodiac. It is designated as the first constellation of the Zodiac. In ancient times, the Sun used



Aries

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Hamal	2.00	85
P	Sheratan	2.64	46
Y	Mesartim	3.90	117

to be in Aries at the time it crossed the celestial equator during its springtime journey in the sky from south to north. That is why the spring or Vernal Equinox is also called the 'First Point of Aries'. It also marks the zero point of right ascension (R.A.), the celestial equivalent of the Greenwich meridian used in geographical maps. Today, however, the Sun does not cross the celestial equator when it is in Aries. Because of the precession of the Earth's axis



The Ram.

(like the wobbling of a spinning top) over the years, and the resulting shift of the celestial pole, this point now actually lies in the constellation of Pisces. But the Vernal Equinox is still called the First Point of Aries. Aries culminates at around 9.00 p.m. during the third week of December.

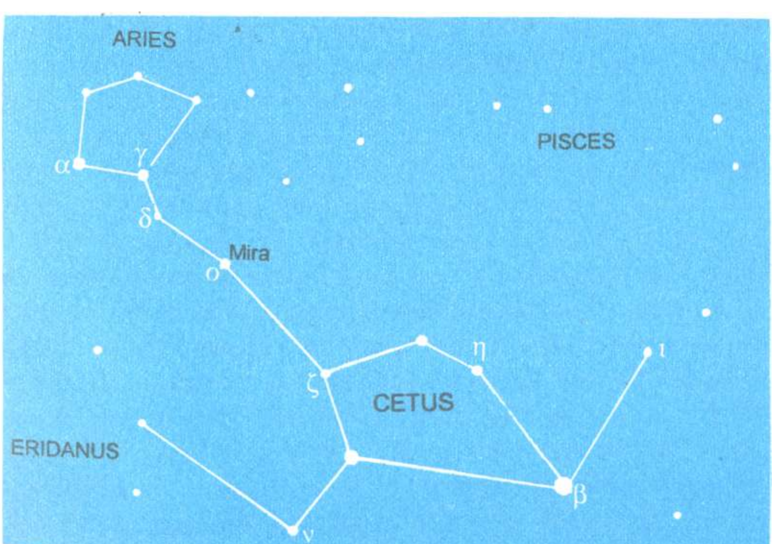
Triangulum

Just to the north of Aries lies the small constellation of Triangulum. As its name suggests, it is a small triangle-shaped constellation formed by three not-so-bright stars.

All the three stars are of the fourth magnitude and can be seen only when the sky is dark and clear. Just to the west of the triangle can be seen a galaxy, M33. Although it is the brightest galaxy in the sky after the famous Andromeda galaxy (see p. 88), M33 is not visible to the unaided eye. But it can be seen with a pair of good binoculars or a moderate-power telescope, particularly on a clear moonless night.

Cetus

One of the most extensive constellations in the sky is Cetus, the Whale, which we can see if we look south of Aries. The constellation is said to contain exactly 100 stars visible to the unaided eye, but we may not be able to spot all of them, especially if we are a city dweller. We can locate the 'head' of the whale—a ring of five atars—south of Aries. Two of the five stars are moderately bright; the star Alpha Ceti has a magnitude of 2.8 and the star Gamma Ceti, a magnitude of 3.6. At the other end, in the 'tail' of the whale is another bright star Beta Ceti, also known as Deneb Kaitos



Cetus

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	**Menkar**	**2.53**	**130**
P	**Diphda**	**2.04**	**69**
7	**Alkaffalijidhina**	**3.47**	**75**
C	**Baten Kaitos**	**3.73**	**189**
I	**Shemali**	**3.56**	**163**

(mag. 2.02). (In some books it is referred to as Diphda.) If we look at the star Alpha Ceti, which is also known as Menkar and forms part of the five-membered ring, with a pair of binoculars we will find it is actually a pair of stars —one moderately bright (mag. 2.4) and orange coloured, and the other much fainter (mag. 5.5) and blue coloured. Together the two form a splendid pair.

The most interesting object in Cetus is the variable orange-coloured star Omicron Ceti, or Mira, which we can find near the head of the whale. It was the first variable star to be discovered by astronomers in the seventeenth century. This star varies so greatly in brightness over a period of time that the seventeenth-century astronomer Johannes Hevelius named it Mira which in Latin means 'the wonderful'. At its minimum Mira dims to almost ninth magnitude so that it is invisible to the unaided eye. But at maximum it brightens up to almost magnitude 3 and may even surpass Polaris in brightness. The change in brightness take place over a very long time—about 331 days, or 11 months—but it is not always regular. On average, Mira is visible without a telescope for only about 18 weeks of its 47-week period. We can locate Mira just south of the tip of the 'V' of Pisces (see p. 89). Once we have located it we must keep watching it for the next few weeks; we will see how its brightness changes with time. Mira culminates at around 9.00 p.m. during the second week of December.

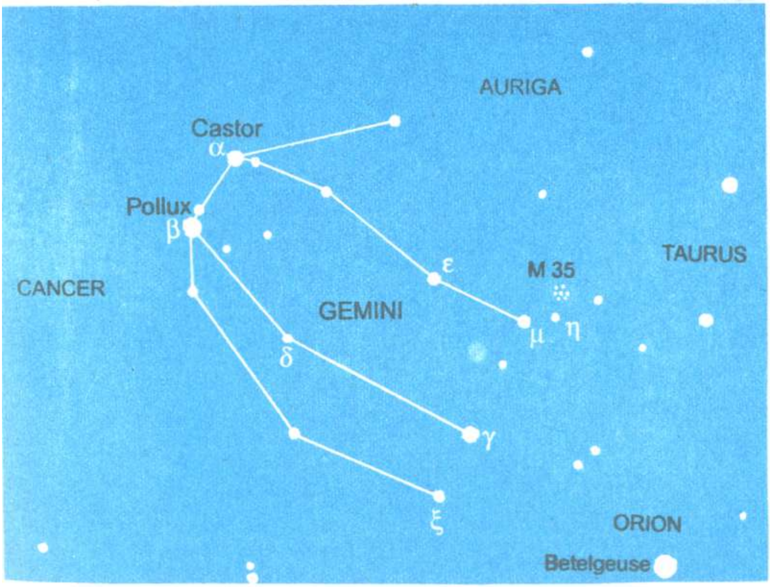
2

THE SKY IN SPRING
(March, April, May)

The spring sky does not offer as rich a fare as the sky in winter. Besides, with the nights growing shorter we have fewer hours at our disposal. But, still, we can enjoy watching two of the brighter zodiacal constellations which offer splendid sights during the spring months.

Gemini

If we turn our gaze to the northeast of Orion (over the



Gemini

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Castor	1.58	46
P	Pollux	1.14	36
Y	Alhena	1.93	85
5	Wasat	3.53	59
e	Mebsuta	2.98	685
n	Propus '	3.10	186
%	Alzirr	3.36	75

Hunter's right shoulder) we will come to the zodiacal constellation of Gemini, the Twins *(Mithuna).* We can easily locate it by using the stars Rigel and Betelgeuse as pointers. If we join these two stars of Orion and extend the imaginary line further up (to the north) we will reach two bright stars close to each other. They are Alpha Geminorum, or Castor and Beta Geminorum, or Pollux *(Punarvasu),* the principal stars of Gemini. A'he two stars are not alike—Castor (mag. 1.6) is bluish-white, while Pollux (mag. 1.2) is orange-red. On a clear night the contrast between them

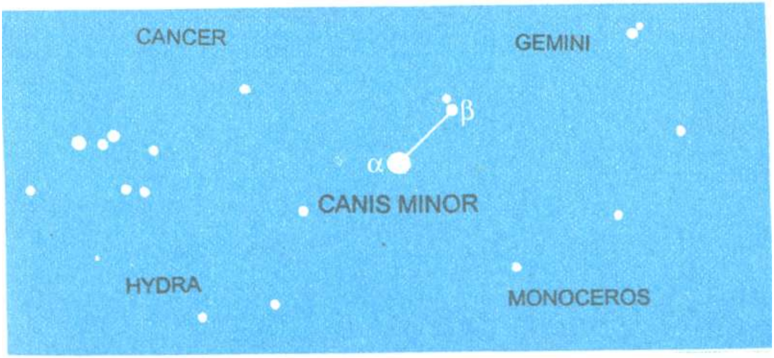
The Twins.

shows how intense the colouration of stars can be. If we look through a telescope (with a magnification of lOOx) we will find that Castor is really made up of two stars close together; but to the unaided eye they appear as a single star. *Punarvasu* is one of the 27 *nakshatras* of Indian astronomy. Castor and Pollux culminate at around 9.00 p.m. during the first week of March.

One of the interesting objects in Gemini is the star cluster M35. We can find it just off the star Eta Geminorum on dark nights if the sky is clear. In low-power binoculars it may look like a dim, fairly large interstellar cloud. But if we look carefully, even through light polluted city skies, a pair of 7x 50 binoculars will reveal at least half a dozen of the cluster's brightest stars against the whitish glow of about 200 others.

Canis Minor

The small constellation of Canis Minor, the Little Dog, can be located easily by its first magnitude star Alpha Canis Minoris or Procyon (mag. 0.5) which lies directly south of Gemini. Procyon can also be located by extending the imaginary line joining the stars Gamma Orionis and Betelgeuse eastward. With Sirius and Betelgeuse, Procyon forms a roughly equilateral triangle, which is also known as the Winter Triangle.

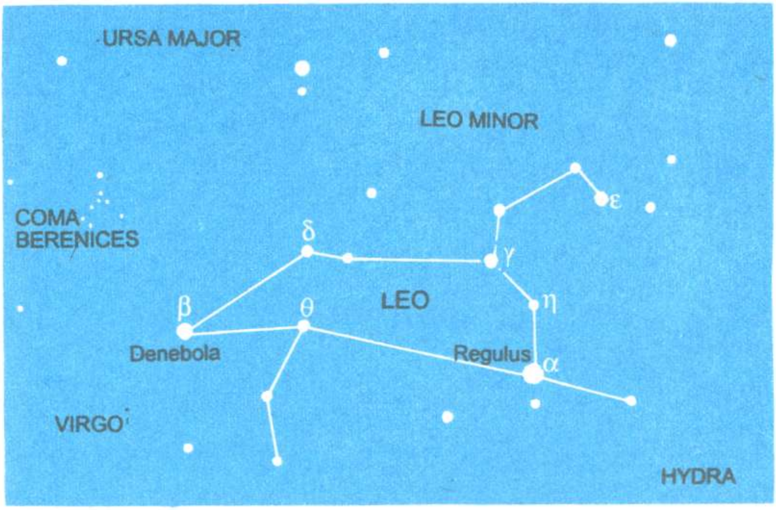


Canis Minor

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Procyon	0.38	11
P	Gomeisa	2.90	137

Leo

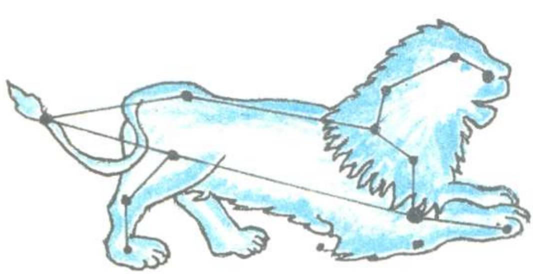
By the first week of March we can see one of the most conspicuous equatorial constellations visible in the night sky. It is Leo, the Lion *(Simha).* We can easily locate it by extending the 'pointers' of Ursa Major, or the Big Dipper backwards. The constellation is easy to recognise by the distinctive form of a 'sickle' made by some of its principal stars. In fact, apart from the Big dipper no springtime asterism is as prominent as the sickle of Leo. If we look up at the constellation when it is culminating, facing south, we can easily make out a distinct shape resembling a lion with the 'sickle' forming its head. The most prominent star in the constellation is Alpha Leonis, or Regulus *(Magha)* which has a magnitude of 1.36. It is located almost right



Leo

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Regulus	1.30	84
P	Denebola	1.60	43
y	Algieba	1.99	190
5	Zosma	2.60	82
e	Asad Australis	2.98	310

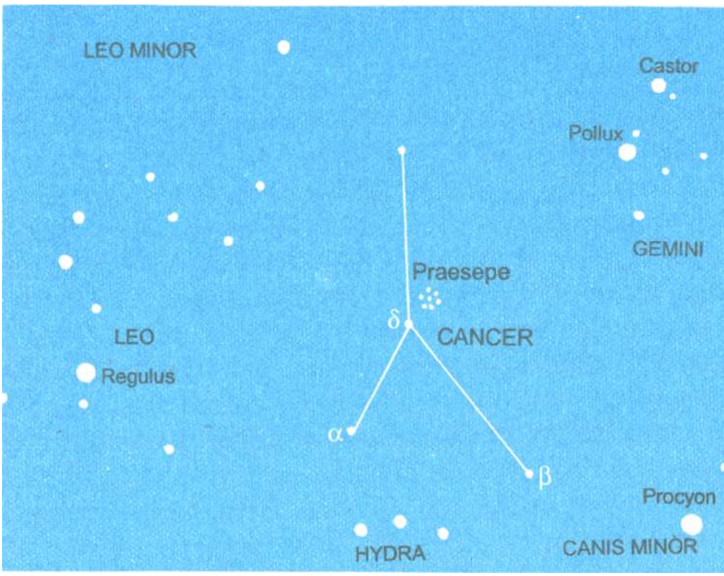
on the ecliptic and marks the bottom end of the sickle. *Magha* is one of the 27 *nakshatras* of Indian astronomy and the Indian month of *Magh* owes its name to this star, because during this month the Moon attains fullness in the vicinity of this star. Regulus is quite close to us— being about 85 light-years away and is about 160 times as bright as the Sun. Another bright star, Beta Leonis, or Denebola (mag. 1.6) marks the lion's tail. In India, Denebola is identified with *Uttara Phalguni* which is also one of the 27 *nakshatras.* The Indian month of *Phalgun* owes its name to this star because during this month the full Moon is seen in the vicinity of this star. The star Delta Leonis, or Zosma (mag. 2.58) is identified with *Purva Phalguni,* which is also one of the 27 *nakshatras.* From most parts of India, Leo is seen almost overhead at culmination. (From southern parts of India it appears slightly to the north.) Regulus culminates at around 9.00 p.m. during the third week of April.



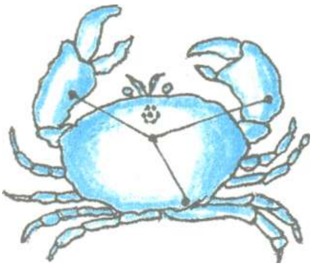
The Lion.

Cancer

Between the constellations of Leo and Gemini lies the zodiacal constellation of Cancer, the Crab *(Karkata).* The constellation is small and rather insignificant as it contains no star brighter than magnitude 4. If we are not able to locate it easily, use needn't get disheartened. If we persist,



we may be able to make out a rough 'Y' shape formed by four faint stars. If we do, we have found the constellation. The only interesting object in Cancer is a beautiful star cluster known as Praesepe, or the Beehive *(Pushya)* which is one of the 27 *nakshatras* f Indian astronomy. The Indian month of *Pous* owes its name to this cluster, because during this month the full Moon is seen in the vicinity of this cluster. On a dark moonless night the Beehive is visible to an unaided eye as a hazy patch, but if we use a pair of binoculars or a medium-power telescope we can see as many as 30 separate stars in the cluster. In India, the star Alpha Cancri (mag. 4.3) is identified with *Aslesa,* which is one of the 27 *nakshatras.* Cancer culminates at around



The Crab.

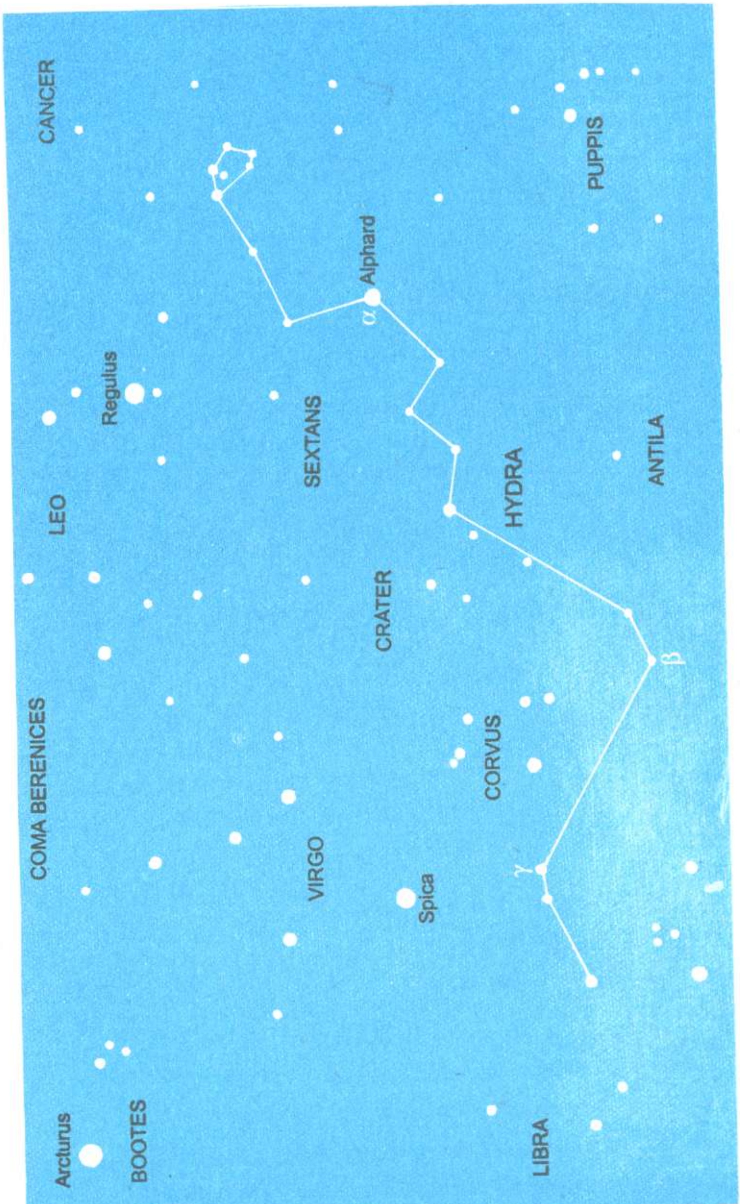
9.00 p.m. during the third week of March.

Hydra

Extending from just below Cancer in the northwest up to the zodiacal constellation of Libra (see page 73) in the southeast is the sprawling constellation of Hydra, the Sea Serpent (map on p.60). Although it is the largest constellation in the sky, Hydra has only one bright star—the yellow-orange Alpha 'Hydrae', or Alphard, of magnitude 1.98—which is supposed to represent the serpent's heart. The name 'Alphard' means 'the solitary one' and indeed it is the only star as bright as the second magnitude in a huge region of the sky. The other stars in the constellation are mostly fainter than the fourth magnitude and can be seen only if the sky is exceptionally clear. Alphard lies to the south of the 'Sickle' of Leo, but we can locate it more easily if we use the stars Castor and Pollux of Gemini as pointers. If we extend the imaginary line joining Castor and Pollux further to the southeast we will reach Alphard. We can't make a mistake in recognising it as there is no other bright star in its neighbourhood. Alphard culminates at around 9.00 p.m. during the last week of March.

Corvus

If we turn our gaze further southeast from Alphard, we will come across the small constellation of Corvas, the Crow. We can locate it a little below to the west of the


CANCER
PUPPIS
Alphard
α
Regulus
LEO
SEXTANS
HYDRA
ANTILA
CRATER
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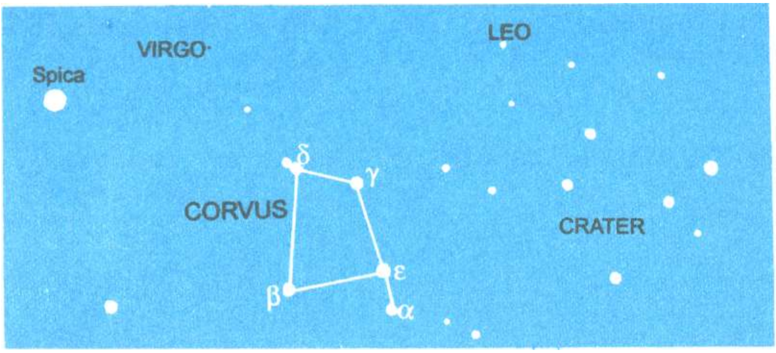
COMA BERENICES
CORVUS
VIRGO
Spica
γ
Arcturus
BOOTES
LIBRA



Corvus

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Alkhiba	4.02	69
P	Kraz	2.65	290
Y	Minkar	2.60	186
5	Algorel	2.90	117
E	–	3.00	104

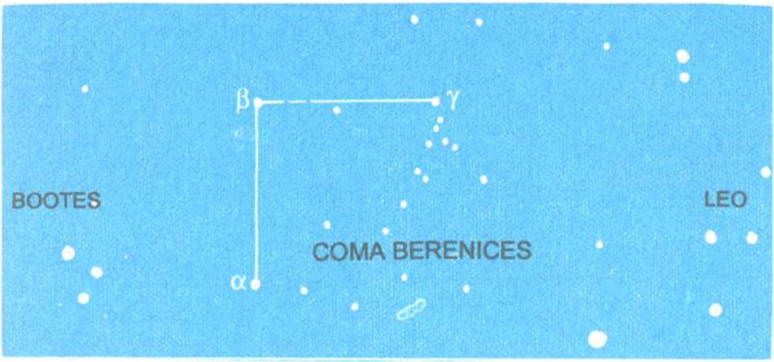
star Spica (see page 65). The constellation itself is rather small and has few bright stars (the brightest star Gamma Corvi has a magnitude of 2.59), but on a dark night you can easily recognise it by its distinctive four-sided rhombus-like figure. In Indian astronomy, the star Delta Corvi (mag. 2.95) is identified with *Hasta* which is one of the 27 *nakshatras.* Corvus culminates at around 9.00 p.m. during the second week of May.

From south of Bhopal, you can see the tiny but bright constellation of Crux to the south of Corvus (see page 26).

Coma Berenices

For anyone with a good eyesight, Coma Berenices, or Berenice's Hair would be an interesting constellation . It is situated almost midway between the constellations of Leo

and Bootes (see page 63) and contains no star of brightness greater than magnitude 4. So, to an unaided eye it



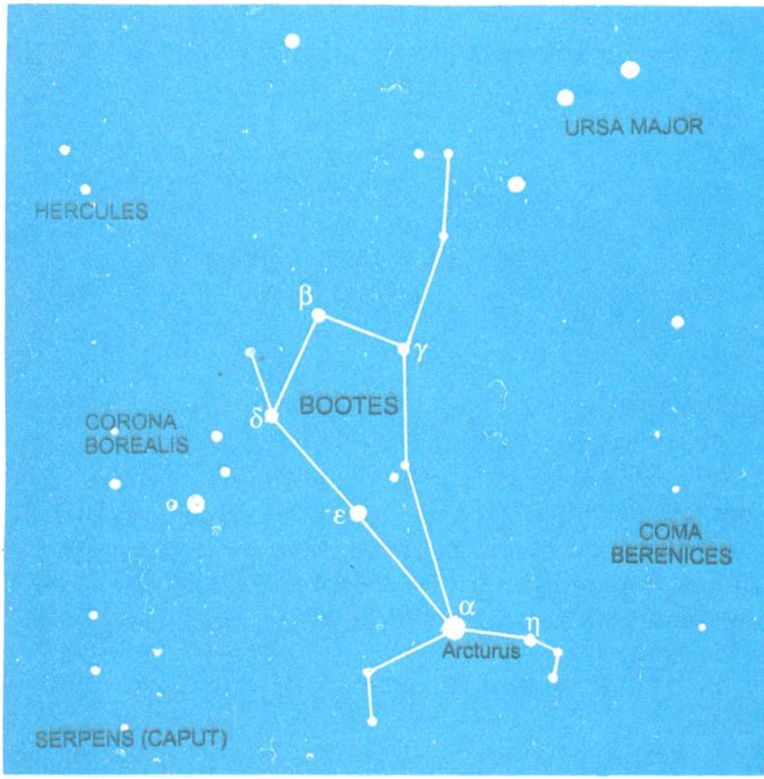
appears as a woolly haze, but we can try to locate a few stars if we can. If we look at it through a pair of binoculars or a low-power telescope, we can see a swarm of stars. With more powerful telescopes many galaxies can be seen in this part of the sky. Coma Berenices culminates at around 9.00 p.m. during the second week of May.

THE SKY IN SUMMER
(June, July, August)

Summer is the worst time for starwatching especially if we live in the north of India. At the peak of summer, really dark nights can be as short as just six hours' duration with nightfall well past 9.00 p.m. If we live in the south we will not face this problem. But even if we are in the north , if we are prepared to stay awake till late night, we may be rewarded with some of the most spectacular constellations of the sky

Bootes

By early June, the Big Dipper is high up in the northern sky and its stars can be conveniently used to locate other constellations. If we look at the stars of the 'handle' of the dipper we would find they roughly form an arc. If we extend this arc further south, we will reach an exceptionally brilliant orange star. This bright star is Alpha Bootis and is commonly known as Arcturus (*Svati),* the predominant star of the constellation of Bootes, the Herdsman. *Svati* is one of the 27 *nakshatras* of Indian astronomy. The brilliance of Arcturus (mag. -0.6) makes the rest of constellation's stars seem dim, but even then, we can easily make out the rough shape of a huge elongated kite with Arcturus at the tail. Arcturus is a giant star having 30 times the diameter of the Sun and is at a distance of 40 light-years from us. The star Epsilon Bootis, also known as Izar (mag. 2.4), is a



Bootes

Star	*Name*	*Magnitude*	*Distance (Light -years)*
a	Arcturus	-0.06	36
P	Nekkar	3.60	137
Y	Seginus	3.03	118
e	Izar	2.37	150
11	Saak	2.80	32

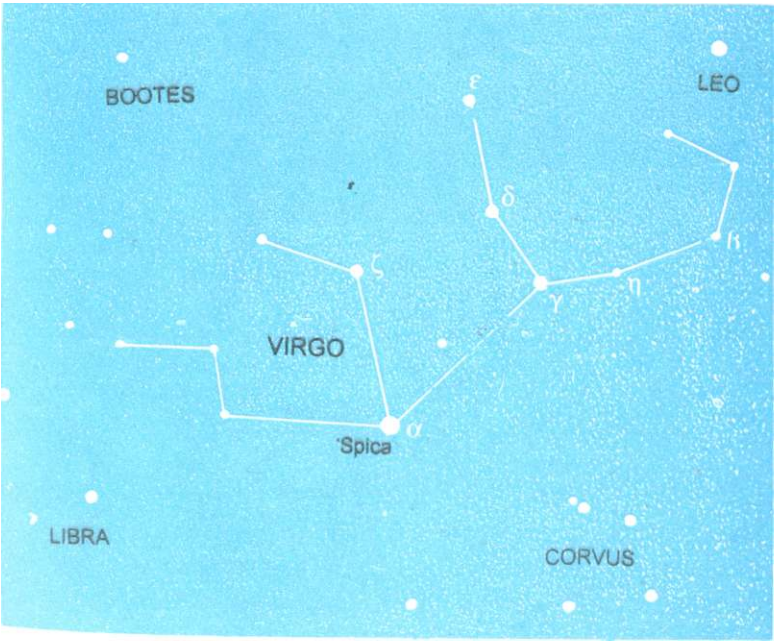
double star, often referred to as one of the most beautiful stars in the sky. But we will need a moderate-power telescope if we want to see its faint companion. This star is also known as Pulcherrima, which means 'Most

Beautiful'. Arcturus culminates at around 9.00 p.m. during the second week of June.

Virgo

If we extend the arc formed by the handle stars of the Big Dipper through Arcturus further south, we will come across another bright white star, Alpha Virginis, or Spica in the constellation of Virgo *(Kanya).* The Indian name of Spica is *Chitra,* which is one of the 27 *nakshatras,* and the Indian month of *Chaitra* owes its name to this star because during this month the full Moon is seen in the vicinity of this star. In the Zcxliac, Virgo lies next to Leo, to the southeast of it. Besides Spica (mag. 0.98), the constellation has a few bright stars—only two of them brighter than the third magnitude—but we can easily make out the shape of a 'bowl' formed by five stars between Denebola in Leo and Spica. Spica culminates at 9.00 p.m. during first week of June.

An interesting point to note here is that with Denebola



Virgo

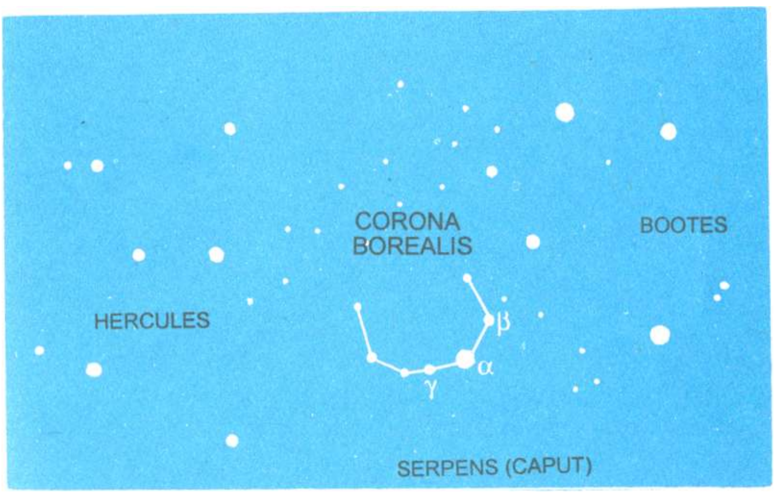
Star	*Name*	*Magnitude*	*Distance (Light -years)*
a	Spica	0.98	260
P	Zavijava	3.60	33
y	Arich	2.80	36
5	Minelauva	3.40	147
£	Vindemiatrix	2.80	104

of Leo and Arcturus of Bootes, Spica forms a distinct equilateral triangle in the sky.

The Virgin.

Corona Borealis

Immediately to the east of Bootes in the northern sky is the beautiful constellation of Corona Borealis, the Northern Crown. Six of its stars form a neat semicircle (the crown) that we can easily identify. Its brightest star Alpha Coronae Borealis is called Gemma (also known as Alphecca). With a magnitude of 2.2 it is set like a jewel in the crown. Corona Borealis culminates at around 9.00 p.m. during last week of June.



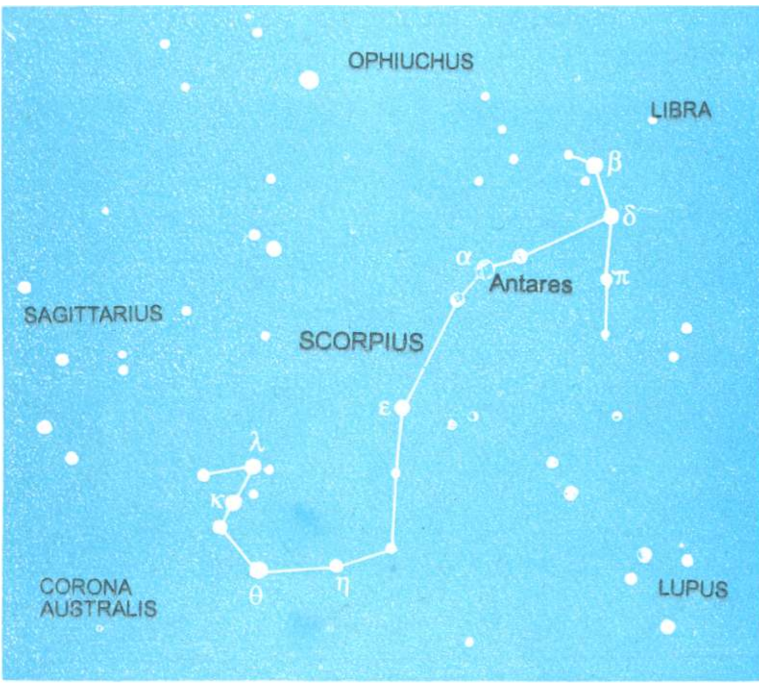
Corona Borealis

Star		*Name*	*Magnitude*	*Distance (Light -years)*
a	v	Alphekka	2.30	76
P		Nusakan	3.70	59

Scorpius

By the second week of June, Arcturus is high up in the sky in the late evenings and so is Corona Borealis, which is almost directly overhead for observers in north India. In the southern sky, the southernmmost zodiacal constellation

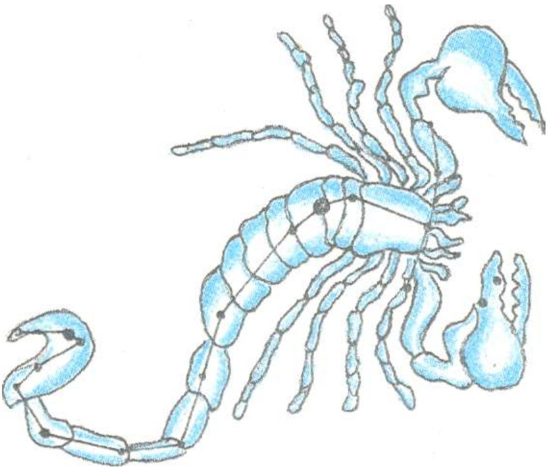
of Scorpius, the Scorpion *(Vrischika)* is slowly making its appearance. When it is fully up, Scorpius is a magnificent sight and can be located easily by its distinct scorpion shape, but we may find it difficult to recognise when it is rising. Of course, we can locate it even then by first spotting its leading star, the orange-red Alpha Scorpii, or Antares



Scorpius

Star	*Name*	*Magnitude*	*Distance (Light years)*
a	Antares	0.96	326
P	Graffias	2.60	815
8	Dschubba	2.32	554
e	Wei	2.30	65
X	Shaula	1.63	274
e	Sargas	1.87	913

mag. 0.98). Antares is a supergiant star with a volume 30,00,000 times that of the Sun and lies at a distance of about 425 light-years from us. The Indian name of Antares is *Jyestha.* It is one of the 27 *nakshatras* in Indian astronomy



The Scorpion.

and the Indian month of *Jyestha* is named after it because during this month the Moon attains fullness in the vicinity of this star. To find Antares, all we have to do is to face south with Corona Borealis directly overhead (around 9.00 p.m. during the first week of July) and look towards the southeastern horizon. Once we have spotted Antares (which we are unlikely to miss because of its bright orange-red colour), it should not be difficult to identify the distinct shape of a scorpion after which the constellation has been named. In the first week of June, Antares culminates at around midnight. But in July it is up quite early in the evening and we can see the whole constellation by 9.00 p.m. or so.

The star Lambda Scorpii (mag. 1.6) is called Shaula, which in Arabic means 'the scorpion's sting'. The Indian

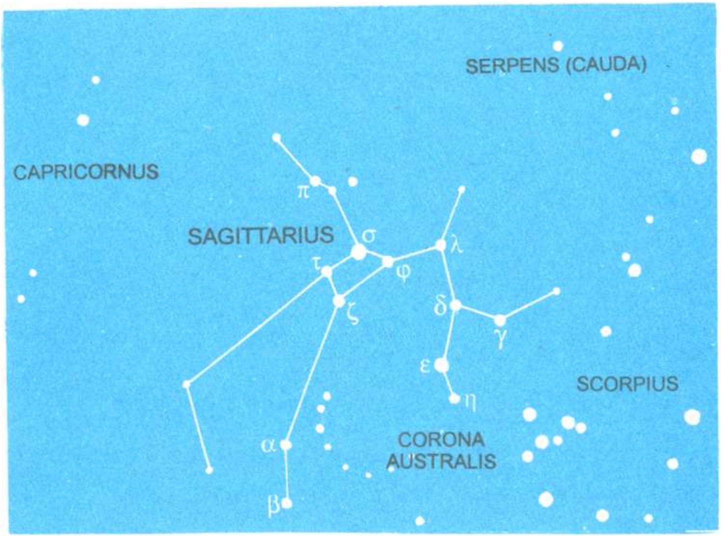
name of this star is *Mula,* which is also one of the 27 *nakshatras.* The third *nakshatra* associated with Scorpius is *Anuradha* which is identified with the star Delta Scorpii.

Scorpius is visible from all parts of India although from northern parts of Kashmir its lower stars may be too near the horizon. From southern parts of the country we can see it quite high up in the sky.

By the first week of July Scorpius is up in the southern sky early in the evenings and is a majestic sight in the night sky. It is particularly so for viewers in the southern parts of India from where the whole constellation can be seen high above the horizon. If the sky is dark and clear, we will also see the whitish band of the Milky Way that passes through the constellation. If we look through a pair of binoculars or a small telescope, we will see innumerable tiny specks of stars that actually make up the Milky Way. Of course, if we live in a big city we may not be that lucky, as the Milky Way is rarely visible in the brightly lit city skies.

Sagittarius

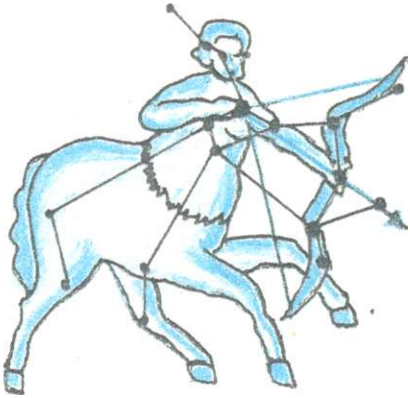
Facing south if we look to the left (east) of Scorpius, we will find the zodiacal constellation of Sagittarius, the Archer *(Dhanu).* It is quite a prominent constellation with many bright stars and can be easily located. Mythologically, Sagittarius is supposed to represent to bow-wielding Centaur (mythical animal which is half-horse and half-man), but we can spot it more easily if we look for the 'teapot' formed by some of its stars. The brightest star in the constellation is bluish-white Epsilon Sagittarii, or Kaus Australis (mag. 1 .8). The star Delta Sagittarii (mag. 27) is identified with *Purvasadha* in India and the Indian month of *Asadha* owes its name to this star because during this month the full Moon is seen in its vicinity. The star Sigma Sagittarii (mag. 2.14) is identified with *Uttarasadha,* which is also one of the 27 *nakshatras.* As the brightest part of the Milky Way runs through Sagittarius, the constellation is



Sagittarius

Star	*Name*	*Magnitude*	*Distance (Light-years)*
g	Alnasr	2.99	117
d	Kaus Merdionalis	2.70	82
e	Kaus Australis	1.85	85
1	Kaus Borealis	2.81	98
s	Nunki	2.02	209
P	Albaldah	2.89	310

rich in faint stars and star clusters. On a clear night as many as ten such clusters can be seen with a pair of binoculars. An interesting point here is that the centre of the Milky Way galaxy of which our Sun and the solar system are a part, lies in the direction of Sagittarius. But the actual galactic centre lies hidden behind dark clouds of inter-stellar dust and is not visible from Earth. However, if we want to find out where it is, look just to the right of the star Gamma Sagittarii (mag. 2.99) which forms the



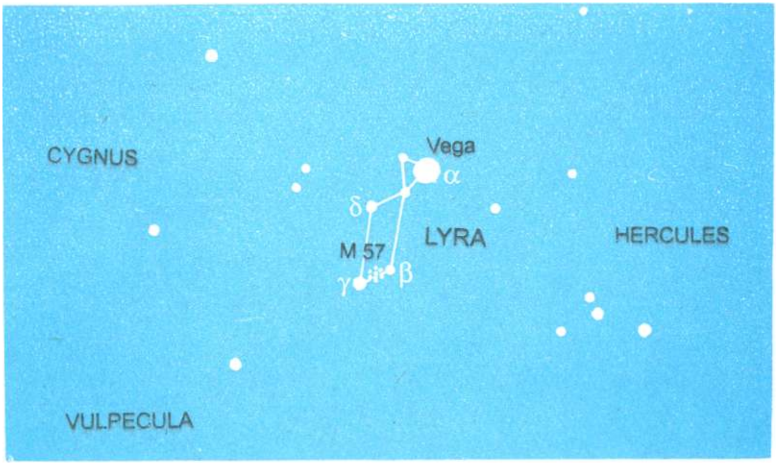
The Archer.

'spout' of the teapot. Sagittarius culminates at around 9.00 p.m. during the third week of August.

Lyra

From Sagittarius, it we turn wer gaze to the northern sky, we can easily spot the brilliant white star, Alpha Lyrae, or Vega *(Abhijit),* which is the principal star in the constellation of Lyra, the Harp. Vega (mag. 0.04) is the fifth brightest star in the sky and lies immediately to the east of Hercules (see page 75). The constellation of Lyra itself is, however, rather small and ill-defined. If we look at it carefully we will find that it is composed of a small parallelogram and a triangle, joined together. The star Epsilon Lyrae, which marks the eastern corner of the triangle opposite Vega, is a remarkable multiple star. If we have a keen eyesight (or with a pair of binoculars) we can easily make out two faint stars (of magnitude 5) in it. A medium-power telescope reveals that each of these two stars is, in turn, a double star. It is a unique example of a double-double or quadruple star system.

Another interesting object in Lyra is the Ring Nebula, M57, which lies between the stars Beta Lyrae and Gamma Lyrae. It is too faint to be seen with the unaided eye or binoculars, but if we look through a medium-power



Lyra

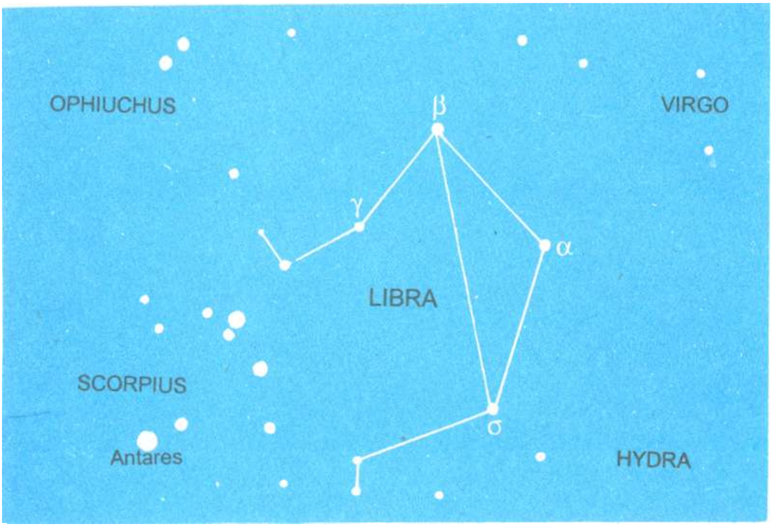
Star	*Name*	*Magnitude*	*Distance (Light -years)*
a	Vega	0.03	26
P	Sheliak	3.40	300
7	Sulaphat	3.24	192

telescope (lOOx or more) we may be able to see it as an elliptical spot. In photographs taken with large telescopes, it appears as a miniature smoke ring. Lyra culminates at around 9.00 p.m. during the third week of August.

Libra

Between Virgo and Scorpius on the ecliptic lies the zodiacal constellation of Libra, the Scales *(Tula).* It is a small and inconspicuous constellation and does not contain any star brighter than magnitude 3. But if we look carefully we may be able to recognise a quadrangle formed by four stars (two of them moderately bright) in the region of the sky midway between Spica and Antares.

The interesting point about Libra is that when the Sun is in this constellation it marks the autumnal equinox,



Libra

Star	*Name*	*Magnitude*	*Distance (Light -years)*
a	Zubenelgenubi	2.90	72
l3	Zubenelchemale	2.61	121

the time when the days and nights are of equal length. This may be the reason why scales were chosen to represent this constellation. Its brightest star Beta Librae is named Zubeneschamali (mag. 2.6). Its second brightest star Alpha Librae, named Zubenelgenubi (mag. 2.9), is actually a double; its companion (mag. 5.2) can be easily seen with a pair of binoculars.

In India, Zubenelgenubi is identified with *Visakha,* one of the 27 *nakshatras* of Indian astronomy after which the Indian month of *Vaisakh* is named. During this month the Moon attains fullness when in the vicinity of this star. Libra culminates at around 9.00 p.m. during the last week of June.

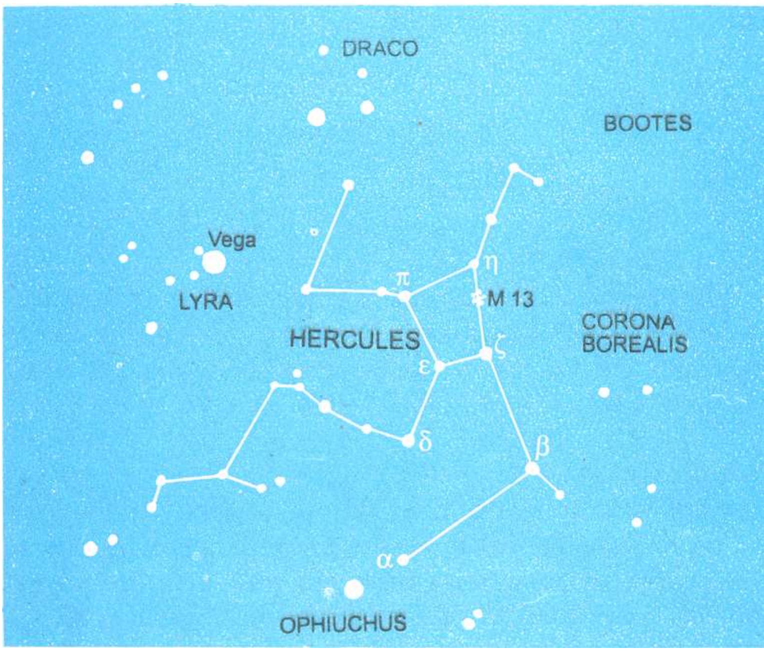
The Scales.

If we are living anywhere south of Bhopal, then we can see the magnificent constellation of Centaurus south of Libra. We can easily locate it by its two bright stars Alpha and Beta Centauri (see also p. 28).

Hercules

Coming back to the northern sky, immediately to the east of Corona Borealis we can see the constellation of Hercules. It is a large constellation covering a wide area in the sky and has more than 140 stars which can be seen with an unaided eye; but none of its stars is brighter than magnitude 3. The constellation is supposed to represent a one-armed an man, an kneeling. Of course, we have to face north to see him in that posture. The simplest way to identify the constellation is to look for the distorted 'H' formed by some of it stars, east of Corona Borealis. A group of four stars—Pi, Eta, Zeta and Epsilon Herculis—makes up a shape known as the 'Keystone', which marks the pelvis of Hercules. The rest of its shape can then be easily traced out. The 'head' of Hercules is marked by the star Alpha Herculis or Ras Algethi (mag. 3.1-3.9). It is a red giant with a diameter of at least 45,000,000,000 kilometres, making it possibly the largest known star.

An interesting object in Hercules is a famous globular cluster known as M13. We may be able to just make it out on a clear night as a hazy spot, just below the star Eta Herculis (mag. 3.5). Situated 34,000 light-years from us, M13 contains more than 500,000 stars and is some 100



Hercules

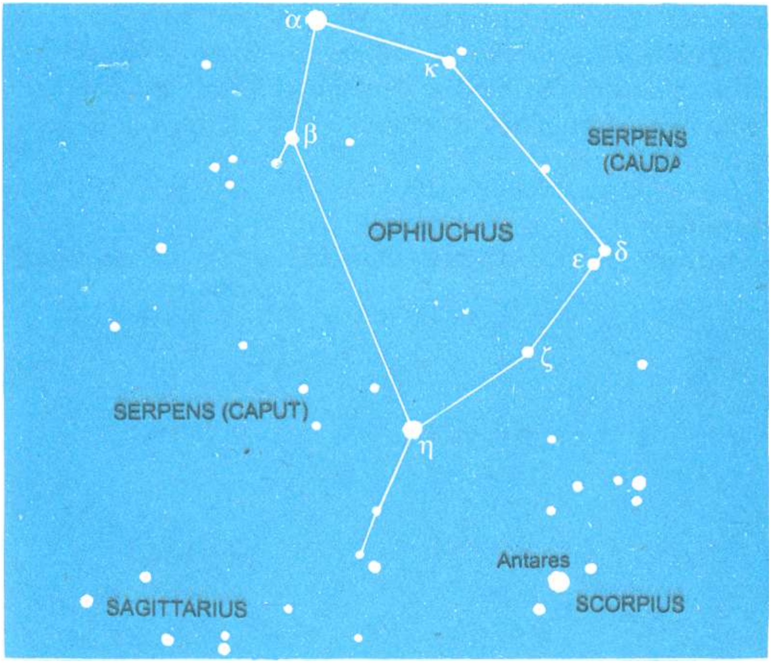
Star	*Name*	*Magnitude*	*Distance (Light -years)*
a	Ras Algethi	3.1-3.9	218
P	Kornephoros	2.80	101
C	Rutilicus	2.80	31
5	Sarin	3.14	91
n	–	3.16	391

light-years across, but it is just visible to the unaided eye. A pair of high-power binoculars or a telescope breaks it up into a myriad of tiny dots. Hercules culminates at around 9.00 p.m. during the third week of July

Ophiuchus

Immediately to the south of Hercules is another huge

constellation, Ophiuchus, the Serpent Bearer. Overall it looks like an immense elongated quadrangle with a triangle on the top (north) of it. The celestial equator passes roughly midway through the resulting pentagon. That is, it is situated exactly halfway between the north and south celestial poles. It also lies exactly midway between the



Ophiuchus

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Rasalhague	2.08	62
b	Cheleb	2.80	121
d	Yed	2.74	140
z	Han	2.56	554
h	Sabik	2.43	59

vernal and autumnal equinoxes. Another interesting point about Ophiuchus is that although a large part of its southern portion lies on the ecliptic, it is not counted as a zodiacal constellation.

Despite its large size, Ophiuchus is a rather dull and barren constellation with few easily visible objects of interest. Its principal star Alpha Ophiuchi, or Ras Alhague (mag. 2.1) lies just to the east of Ras Algethi of Hercules and can be easily located. With a pair of powerful binoculars or a telescope we can pick out a couple of globular clusters within the pentagon south of the equator. Ophiuchus culminates at around 9.00 p.m. during the first week of August.

Serpens

Spanning both sides of Ophiuchus is an unusual

Serpens

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Unukalhai	2.65	85
m	–	3.54	143
h	–	3.26	52

constellation named Serpens, the Serpent, which consists of two disjointed parts. The western part is called Caput ('head') and the eastern part Cauda ('tail'). The constellation itself is faint and insignificant as if contains only one star, Alpha Serpentis or Unukalhai (the 'neck') which is brighter than magnitude 4. On a clear night, we may be able to locate a small triangle of faint stars forming the 'head' of the serpent below Corona Borealis.

Serpens has a beautiful globular cluster M5, which we can spot immediately to the west of Unukalhai. Through a pair of binoculars or a small telescope it looks very much like the M13 cluster in Hercules. The constellation also has a bright diffuse open star cluster M16 which we can see south of the star Eta Serpentis. If we try we may be able to see about 50 stars with the help of a pair of binoculars or a small telescope. M16 lies in the 'tail' part of the serpent. If we want to spot it quickly, we can look at the region midway between Antares and the brilliant star Altair in the constellation of Aquila (see p. 83).

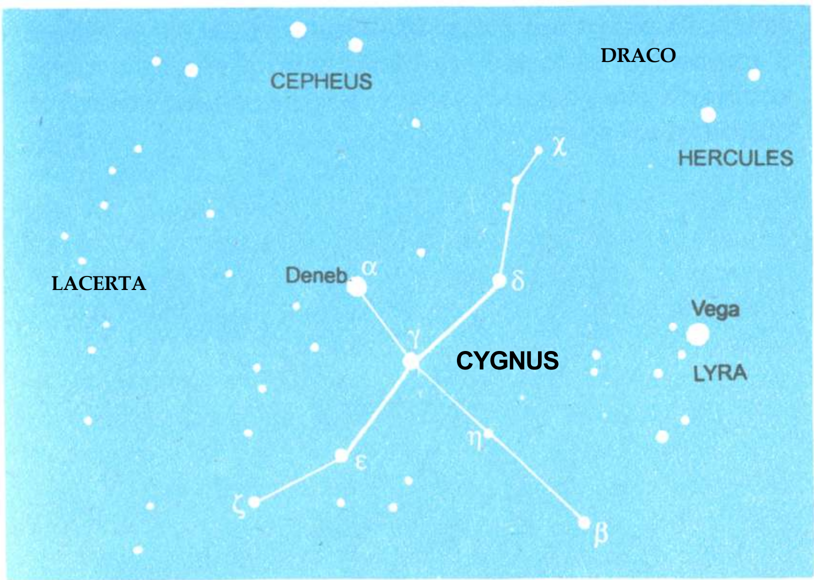
THE SKY IN AUTUMN
(September, October, November)

After the monsoon rains the autumn sky appears crystal clear, with little dust and smoke. Moreover, by September the Sun sets early, making longer periods of darkness available for starwatching. This is also the time when we can see the famous Andromeda Galaxy, the farthest object visible to the unaided sky.

Cygnus

To the east of Lyra is a beautiful constellation Cygnus, the Swan. One of the most prominent constellations of the northern sky, its stars are supposed to represent a flying swan which they do remarkably well. Its brightest star is Alpha Cygni, or Deneb (mag. 1.25) which forms the 'tail' of the swan. Deneb is one of the biggest giant stars known, being about 70,000 times brighter than the Sun and lies at a distance of 1825 light-years from us. The star Beta Cygni, or Albireo (mag. 3.0) forms the head of the swan. The stars Delta Cygni (mag. 2.87) and Epsilon Cygni (mag. 2.46) form the wing tips of the swan. Together the five main stars of the constellation form a distinct 'cross' with Deneb at its top. For this reason it is also known as the 'Northern Cross'. Deneb culminates at around 9.00 p.m. during the third week of September.

Albireo is the faintest of the five stars that make up the cross. But if we look through a pair of good binoculars



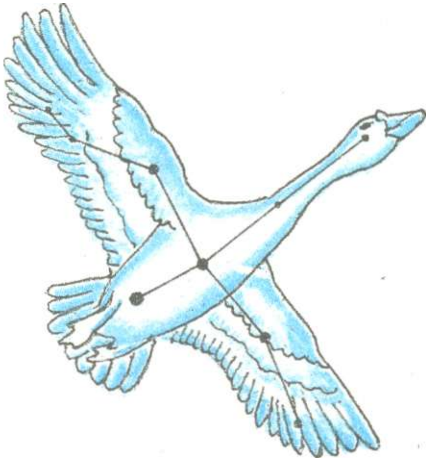
Cygnus

Star	*Name*	*Magnitude*	*Distance (Light-years)*
α	Deneb	1.25	1825
β	Albireo	3.08	390
γ	Sadr	2.20	750
δ	–	2.87	160
ε	Gienah	2.46	82

or a medium-power telescope we will find it to be a double star made up of a golden-yellow star with a fainter, bluish-green companion.lt is said that Albireo is the most impressive double star in the sky. We can find it out ourselves.

Another object worthy of attention is the star Chi Cygni which lies almost midway between the stars Beta Cygni and Gamma Cygni. It is what astronomers call a long-period variable. Its brightness changes from magnitude 4.5 to almost invisible magnitude 14 within a

span of about 400 days. When it is in its brighter phase we can easily pick it out, but in its dimmer phase we may find it impossible to locate. So if we cannot see it now, we shouldn't lose heart. All we need to do is wait till it brightens up again.



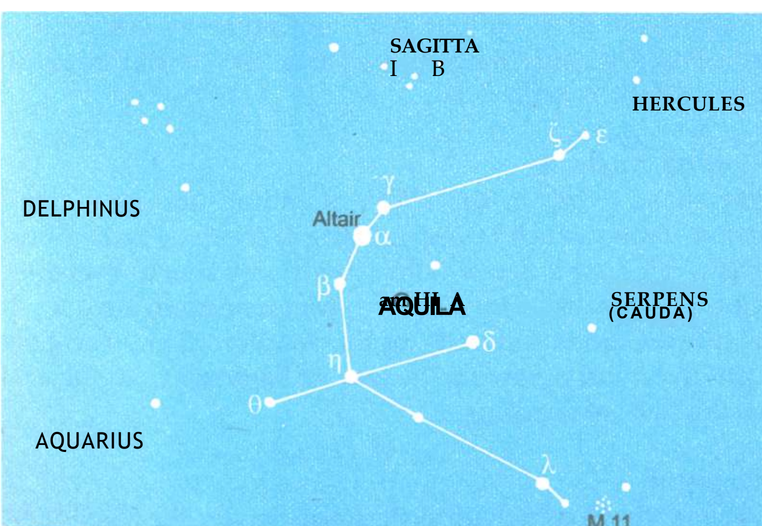
The Swan.

Since the Milky Way passes right through Cygnus, the constellation is rich in star fields and clusters and contains several interesting objects. Immediately to the east of Deneb is the famous 'North America' nebula (NGC7000) which is so called because of its striking resemblance to the outline of that continent. The nebula is not visible to the unaided eye, but on a clear, moonless night, far away from city lights, we can pick it out with a pair of binoculars (10 x 50). Another interesting object is the open cluster M39 which lies northeast of Deneb. We can easily make out the individual stars with a pair of binoculars. Viewers in southern parts of India will see both Lyra and Cygnus over the northern horizon although from north India both can be seen almost overhead at the time of culmination.

Aquila

If we turn our gaze south of Cygnus, we will come to a brilliant white star Alpha Aqulae, or Altair *(Shravana)* in the constellation of Aquila, the Eagle. The constellation is supposed to look like the side view of an eagle with Altair (mag. 0.80) as one of its glittering eyes. We can easily identify Altair because it is flanked on two sides by fainter stars, like guarding sentinels. Along with Vega and Deneb, Altair forms what astronomers call the 'Summer Triangle' although the three are best visible in autumn. *Shravana* is one of the 27 *nakshatras,* and the Indian month of *Shravan* owes its name to *Shravana* as during this month the Moon attains fullness when seen in its vicinity. Altair culminates at around 9.00 p.m. during the first week of September.

To the southwest of Altair and just west of the star Lambda Aquilae (mag. 3.44) is a beautiful star cluster Mil. A group of about 200 stars visible only through a pair of binoculars or a telescope, it is also known as the 'Wild Duck' cluster. It gets its popular name because its stars are arranged in a fan-shape, like a flight of wild ducks, with a



brighter orange star at the apex. We can see the individual stars more clearly if we use a powerful telescope. Mil is

Aquila

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Altair	0.77	17
P	Alshain	3.71	36
Y	Tarazed	2.72	284
X	Althalimain	3.44	98
C	Dheneb	2.99	–
5	–	3.36	52

part of a tiny constellation called Scutum, the Shield, which has no stars brighter than magnitude 5.

Delphinus

If the sky is clear, we can see the tiny constellation of Delphinus, the Dolphin, just to the northeast of Altair. The constellation does not have any star brighter than magnitude 3.5. But if we look carefully it is possible to spot a small group of five stars. In Indian astronomy, the star Beta Delphini (mag. 3.54) is identified with *Dhanistha,* one of the 27 *nakshatras.*

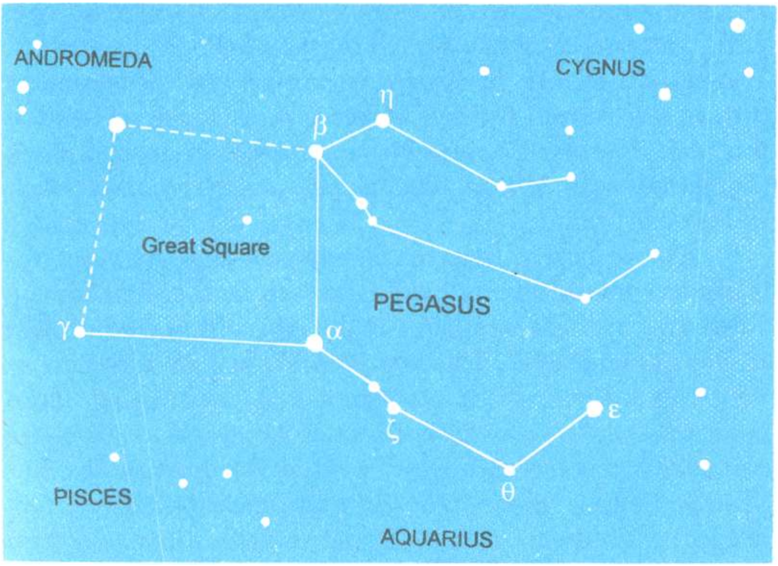
Corona Australis

For those living in the south of India, there is a small constellation which is worth trying to locate. Formed by a chain of about a dozen faint stars it very much resembles Corona Borealis as its stars too form a neat semi-circle. It is called Corona Australis, or the Southern Crown and we can find it just below the 'teapot' of Sagittarius, to the east of the 'tail' of Scorpius.

Pegasus

When Cygnus is high up in the northern sky, the Big Dipper is setting on the northwestern horizon. In the northeast,

Cassiopeia is already up. At this time of the year, around mid-September, we can see the constellation of Pegasus, the Winged Horse, immediately to the east of Cygnus. We can easily locate it by the 'Great Square' formed by four of its brightest stars. (One of the four stars, Alpheratz, forming the northeast corner of the square, actually belongs to the neighbouring constellation of Andromeda, but is conventionally included in Pegasus.)

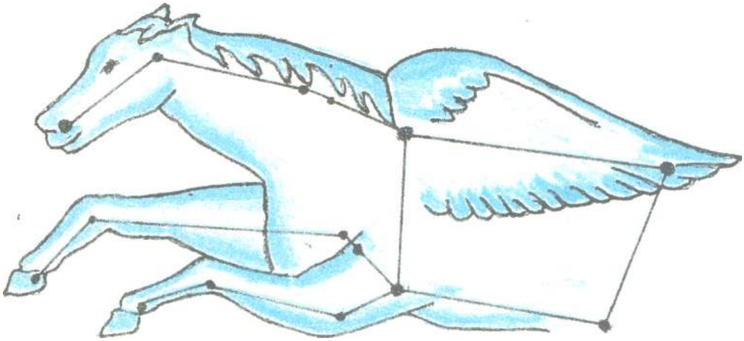


Pegasus

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Markab	2.49	101
P	Scheat	2.40	176
Y	Algenib	2.83	490
e	Enif	2.38	522
1	Matar	2.94	173
s	Homan	3.40	156

If we look up at Pegasus facing north we can imagine the figure of a leaping horse. The chain of three stars stretching from the southwest corner of the Great Square forms the neck and head of the horse with the star Epsilon Pegasi, or Enif marking the nose. The stars west of the northwest corner of the square make up the prancing forelegs of the horse while the chain of stars stretching east from the northeast corner of the square (which form part of the Andromeda constellation) form Pegasus's hind legs. The star Alpha Pegasi, or Markab (mag. 2.57) is identified with *Purva Bhadrapada* which is one of the 27 *nakshatras.* The Indian month of *Bhadra* is named after this star as during this month the full Moon is seen in the vicinity of this star. The star Gamma Pegasi or Algenib (mag. 2.83) is identified with *Uttara Bhadrapada,* another *nakshatra* of Indian astronomy.

The square of Pegasus is extensive and striking, but is almost devoid of any bright star. In fact, except for the Great Square there is nothing in the constellation of interest to the unaided eye. The star Beta Pegasi, also known as Scheat, is a red giant and varies in brightness from magnitude 2.4 to 2.7.There is a globular cluster M15 in the constellation which we can locate to the west of the star Epsilon Pegasi. If we look through binoculars or a small telescope it appears as a misty patch. With more powerful

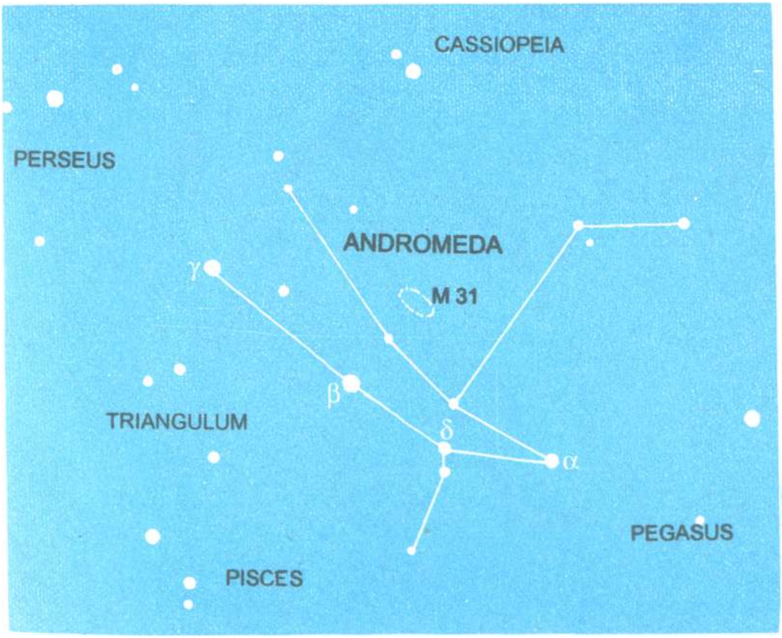


The Winged Horse.

telescopes we can see the individual stars that make up the cluster. We can see the square of Pegasus directly overhead at around 9.00 p.m. during the first week of November.

Andromeda

Stretching from the northeast corner of the Square of Pegasus, and to the east of it,we can see a chain of four bright stars that forms the most prominent part of the constellation of Andromeda. In combination with the Square, this chain of stars forms a sort of an immense 'saucepan' in the sky. The brightest star in Andromeda is Alpha Andromedae, or Alpheratz (mag. 2.06) which forms the northeast corner of the Square of Pegasus. But the most interesting star in the constellation is Gamma Andromedae, which is a double made up of a yellow star (mag. 2.2) and a blue companion of magnitude 5. We can



Andromeda

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Alpheratz	2.06	72
P	Mirach	2.06	88
y	Almaak	2.18	121
5	–	3.2 7	160

easily make out the two separately though a small telescope. The colour contrast is one of the most striking in the sky.

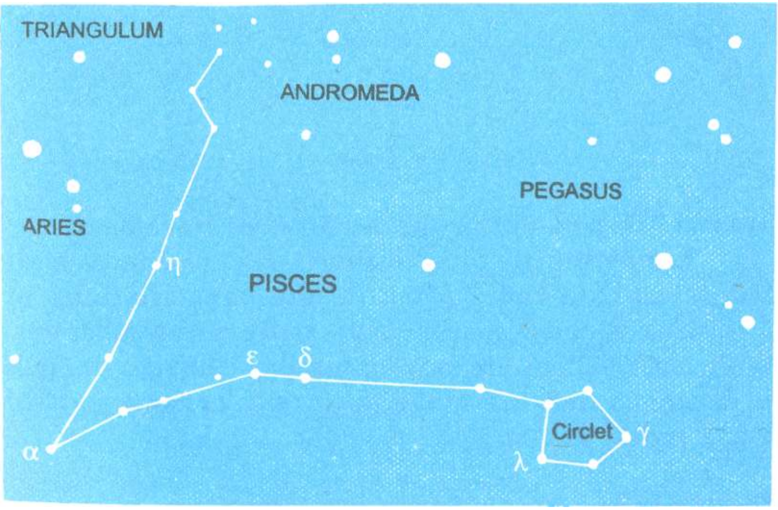
On a dark, clear night we can see the farthest object visible to the unaided eye in the constellation of Andromeda. It is the great Andromeda Galaxy (M31), a vast spiral galaxy similar to our own Milky Way galaxy, lying at a distance of almost two million light-years away from us. On a clear night, away from city lights, it appears as an elongated hazy patch to the northwest of the star Beta Andromedae.

Andromeda.

With a pair of binoculars or a telescope we can see its elliptical shape more distinctly. But if we want to see its real splendour we have to look at photographs taken through a large telescope with long time-exposures. Andromeda galaxy culminates at around 9.00 p.m. during the second week of November.

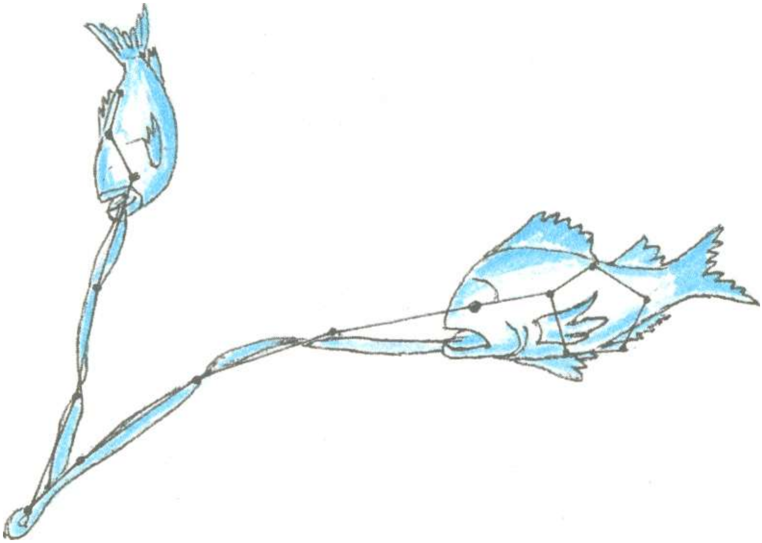
Pisces

To the southeast of the Square of Pegasus lies the zodiacal constellation of Pisces, the Fishes *(Meena).* The constellation consists mostly of faint stars and is quite unimpressive. But we can locate it by the ring of five faint stars (called the Circlet) just below the Square. Extending to the east of the Circlet in the general neighbourhood of the southeastern corner of the square, if we look carefully, we can make out a large 'V' formed by a chain of faint stars. The upper (northern) end of the V lies just below the star Beta Andromedae. This V-shaped chain of stars and the Circlet together form the constellation proper. There is no object of special interest in Pisces. Pisces culminates at



Pisces

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	A1 Rischa	3.79	99
Y	–	3.69	156
11	Alpherg	3.62	143



The Fishes.

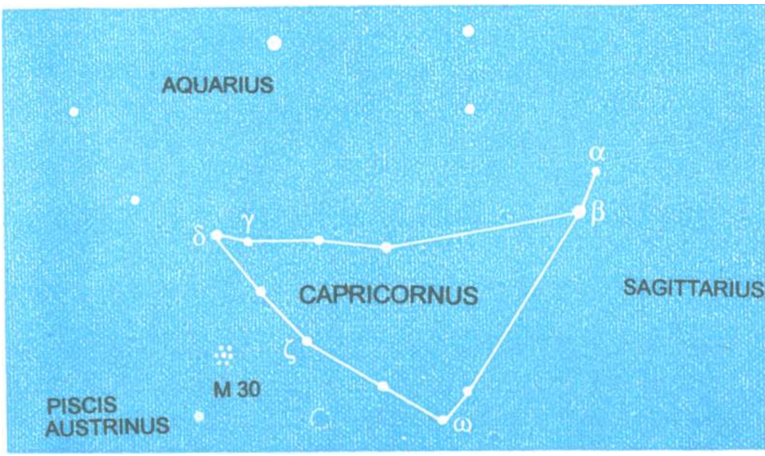
around 9.00 p.m. during the last week of November.

Returning to the southern sky, to the east of Sagittarius on the Zodiac lie the constellations of Capricornus and Aquarius, both zodiacal constellations. Both constellations are, however, rather dull and difficult to locate as they are made up mostly of faint stars of magnitude 4 or more.

Capricornus

Capricornus, the Sea Goat *(Makara)* can be seen directly

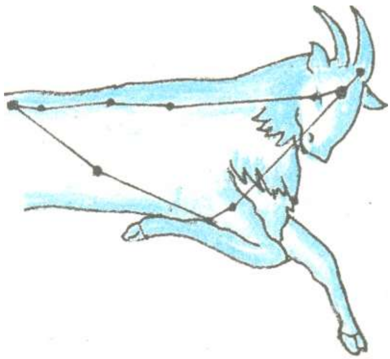
south of Cygnus, although at quite a distance from it. We can locate it easily by extending the imaginary line joining Vega with Altair further down (south) by almost the same distance. If we look carefully, and if the sky is clear, we



Capricornus

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a^1	AlGiedi	4.24	1600
a^2	–	3.57	117
P	Dabih	3.08	104
Y	Nashira	3.68	59
8	Deneb al Giedi	2.87	49

can make out what looks like the shape of a boat formed by faint stars, although it is supposed to represent a goat with a fish tail. Capricornus has two interesting multiple stars. The star Alpha Capricorni is a double star of which the two component stars can be seen with the unaided eye. Small telescopes will show that each of the two is a double with still fainter companions. The star Beta Capricorni is also a double, but its two components can be seen separately only with a pair of binoculars. The brighter



The Sea Goat.

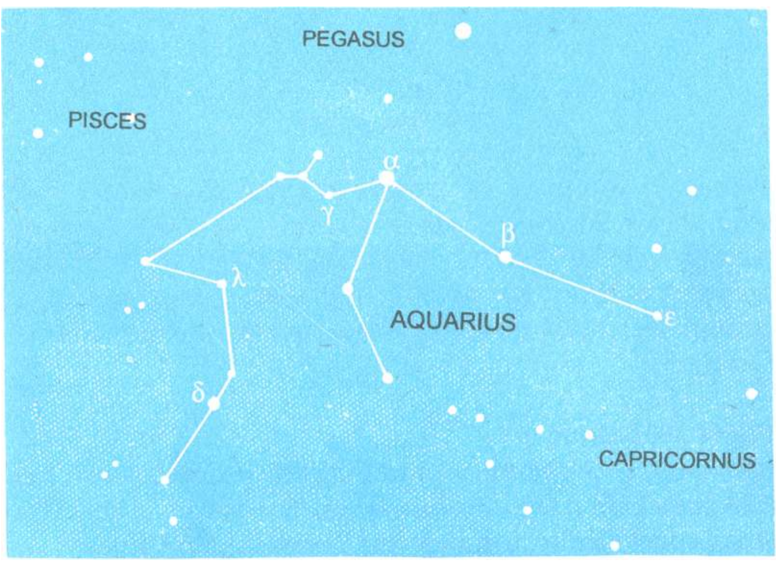
of the two (mag. 3.0) is of yellow colour and the fainter one (mag. 6.0) coloured blue. The constellation also has a globular cluster (M 30) which we can spot to the left of star Zeta Capricorni (mag. 3.74). In binoculars, it appears as a hazy star. Capricornus culminates at around 9.00 p.m. during the last week of September.

The Sun passes through Capricornus from late January to mid-February. In ancient times the Sun used to be in Capricornus at the winter solstice, its farthest point south of the equator. But it does not do so now as the effect of precession has moved the winter solstice into the neighbouring constellation of Sagittarius. Yet, the latitude on Earth at which the Sun appears overhead on that day (December 22) is still known as the Tropic of Capricorn. According to the Indian calender the Sun moves from Sagittarius to Capricornus on January 14 every year—the day celebrated as *Makar Sankranti* in India (although the transit now takes place on January 19).

Aquarius

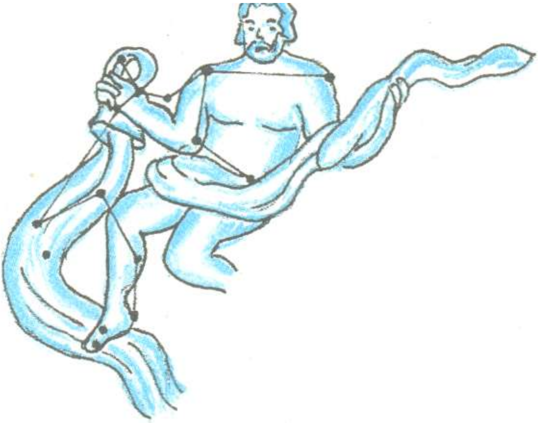
Next to Capricornus on the Zodiac is the constellation of Aquarius, the Water Bearer *(Kumbha).* Though it covers a large area, it is an obscure constellation having only one

star as bright as the third magnitude. The best way to find it is to use the stars Beta Pegasi and Alpha Pegasi as rough pointers. South of Pegasus, if we look just below the star Theta Pegasi we will find (after some effort, maybe) a small group of four still fainter stars—one symmetrically surrounded by three others—forming a 'Y'. The uppermost (northernmost) star of the group is the faintest and may not be always visible (depending on the sky condition. But once we have located it, it will not be difficult to spot. The



Aqaurius

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Sadalmelik	2.96	945
P	Sadalsuud	2.91	978
y	Sadachiba	3.84	91
5	Scheat	3.27	98
e	Albali	3.77	33



The Water Bearer.

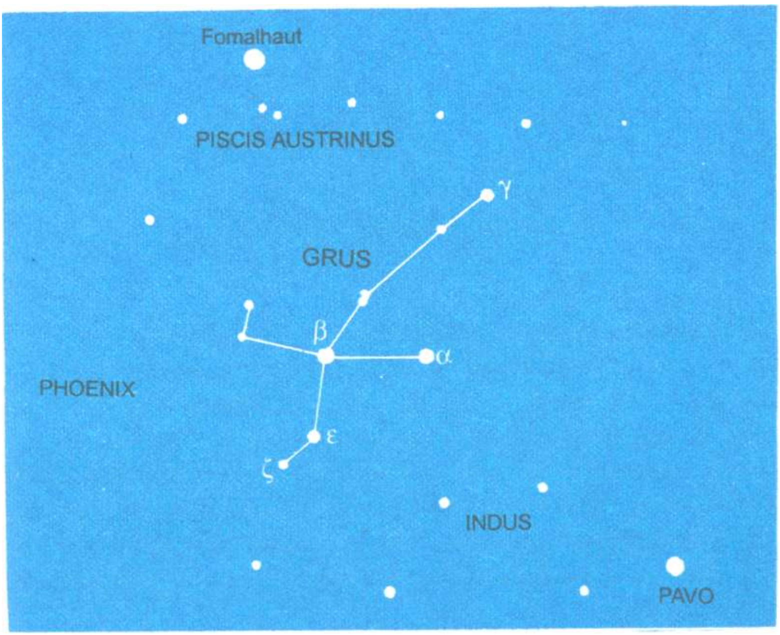
Y-shaped group is supposed to form the 'Water Jar' after which the constellation is named. The star Lambda Aquarii (mag. 3.8) is identified with *Satabhisaj,* one of the 27 *nakshatras* of Indian astronomy. Aquarius culminates at around 9.00 p.m. during the second week of October.

Piscis Austrinus

Just south of Aquarius and to the east of Capricornus lies the constellation of Piscis Austrinus, the Southern Fish. This small constellation is dominated by the brilliant blue-white star Alpha Piscis Austrini, or Fomalhaut (mag. 1.2), which in Arabic means fish's mouth. Since there is no other star of similar brightness in that part of the sky, we will not find it difficult to locate. From north India, Fomalhaut is seen rather low over the southern horizon, but it can be seen quite high up in the sky from southern parts of the country. Fomalhaut culminates at around 9.00 p.m. during the third week of October.

Grus

South of Piscis Austrinus, we can see the small constellation



Grus

Star	*Name*	*Magnitude*	*Distance (Light-years)*
a	Alnair	1.76	64
P	A1 Dhanab	Variable	280

of Grus, the Crane. It is ah easily recognisable constellation, especially if we live south of Bhopal. It has only two bright stars—Alpha Gruis, or Alnair (mag. 1.7) and Beta Gruis, or A1 Dhanab (mag. 2.2). On a clear night we can easily make out the likeness of flying crane in the star pattern.

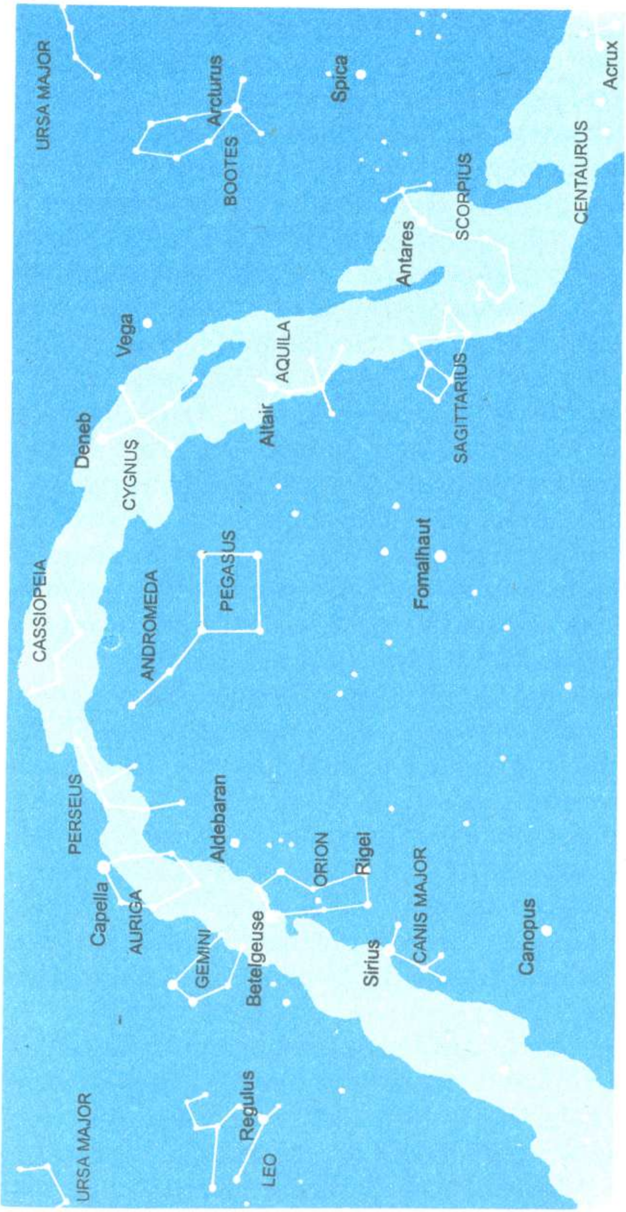
7

THE MILKY WAY

When watching the constellations in the night sky we can see a faint whitish band of light stretching across the sky in a generally north-south direction at certain times of the year. This band of light is the famous Milky Way or *Akash Ganga.* Although we may not realise it when we look at it with the unaided eye, the Milky Way is really made up of countless billions of stars. We can make out the stars as tiny dots of light on looking through a pair of binoculars or a telescope.

In the night sky, the Milky Way appears to pass through a number of prominent constellations. From Cassiopeia in the north it runs south through Perseus, Auriga, Taurus, and between Gemini and Orion towards the Southern Cross. Then it turns north, passing through Scorpius, Sagittarius, Aquila and Cygnusback to Cassiopeia. If we observe car2fully we will notice that the outlines of the Milky Way are irregular; its width varies widely along its length and its brightness changes from point to point. In some areas it appears to be split into two parallel streaks.

An interesting point here is that 16 of the 21 first magnitude stars (except Achernar, Spica, Arcturus, Regulus and Fomalhaut) lie within, or close to, the Milky Way. When they are visible, so also should be the Milky Way. But, unfortunately, in cities the glare of lights and pollution almost completely blots it out except when the sky is exceptionally clear, for instance, after the monsoon rains, or when there



The Milky Way.

is a total power failure!

The best time to see the Milky Way is on an autumn or winter evening. It is then highest in the sky and therefore its visibility is least affected by atmospheric haze. If we scan the length of the whitish band with a pair of binoculars we may be able to see some interesting objects. Apart from a general background of tiny dots of stars, we will find there are gorgeous star clusters and hazy luminous patches in which a great many stars may be embedded. We will also find large, dark areas here and there, which are nothing but thick clouds of interstellar dust which obscure the light coming from the stars behind. The most famous of these dark areas is the so-called Coal Sack, which can be seen just to the bottom left of Crux in the southern sky. The Coal Sack is by no means unique. There are many similar dark areas in the Milky Way, though they are less clearly defined and less striking in appearance.

Although the Milky Way appears as a band of light from Earth, in reality, it is an enormous spiral galaxy within which our Sun and the solar system are situated. The Galaxy (the Milky Way galaxy is also known as the Galaxy, with a capital G) has a general shape of a thin disc with a thick centre which has an estimated diameter of the outermost spiral of about 100,000 light-years. The Sun and the solar system lie about two-thirds of the way from the centre to the outer rim of the Galaxy. It is because of the flatness of the spiral disc that, looking towards its edge from Earth, we see it as an uneven band of stars. Above and below the plane of the disc there are not many stars and so we can see the emptiness beyond the stars into the vast reaches of the universe.

As seen from Earth, the centre of the Galaxy lies roughly in the direction of the constellation of Sagittarius and so naturally is the densest part of the Milky Way. But because of the great density of interstellar dust and gas and the great distance from Earth, the galactic centre has never

been observed optically. We can never see it with even the most powerful telescope. But astronomers have found out a lot about it by using radio telescopes as radiowaves given off by stars which can pass through dust clouds. It is around the galactic centre that the entire spiral-shaped swarm of stars including our Sun and the planets rotates slowly, completing one revolution in about 200 million years.

The Milky Way can offer us hours of exciting viewing if we have access to a telescope with a magnification of lOOx or more. Of course, we have to go to a really dark place, far away from the city lights to have the best view.

7

CELESTIAL WANDERERS

Once we become familiar with the constellations we will be able to identify them in the sky without much effort. And then we can find out a stranger in a constellation—a 'star' which ought not to be there as it is not part of the constellation. If we find such a stranger we shouldn't be surprised, for what we have spotted would most probably be a planet, a member of our own solar system.

One of the most distinguishing features of the planets is that, unlike the stars the positions of which remain unchanged in the night sky, the planets keep moving in the background of the 'fixed' stars over a period of time, ranging from a few days to several months. In fact, it was for this reason that they are called planets, which in Greek means 'wanderers'. Planets are different from stars in another respect. Unlike the stars which shine by their own light, planets shine by reflected sunlight only, as does our Moon. But, being distant, they all appear as mere points of light to the unaided eye like any other star. In a telescope, however, their shapes can be made out easily.

Of the eight planets of the solar system, excluding Earth, only five—Mercury, Venus, Mars, Jupiter and Saturn—are visible to the unaided eye. Uranus, Neptune and Pluto can be seen only with powerful telescopes. But, to spot a planet we would need to be familiar with the zodiacal constellations, and the ecliptic. The path of the planets in the sky lies within a narrow belt north and south of the ecliptic; they can never be found far away from it. In a way, this is of great help in locating the planets.

Another point to remember is that, on summer nights, the ecliptic lies south of the celestial equator. So, any planet visible at that time will also be found low on the southern horizon and will be visible for a few hours only. On the other hand, in winter, the Sun is south of the equator and so at night the ecliptic lies north of the celestial equator. Planets visible on winter nights are, therefore, always high up in the sky—often directly overhead—and are visible for much longer hours. For this reason, the winter months (December-February) are the best time for observing the planets.

As the planets and Earth orbit the Sun, each at a different speed, they all change their position in our sky relative to each other and to the Sun. When a planet is in the sky in the same direction as the Sun, the planet is said to be in conjunction with the Sun. When a planet is seen in the sky in a direction opposite that of the Sun, it is said to be in opposition to the Sun. Since the orbits of Mercury and Venus lie within that of Earth, none of them can ever be seen in the sky in a position directly opposite to the Sun. Hence they can never be in opposition to the Sun. Known as the inferior planets, these two planets are twice in conjunction with the Sun, once when they come between the Sun and Earth, known as 'inferior conjunction', and again when they are on the other side of the Sun so that the Sun comes between them and Earth. In this position, an inferior planet is said to be in 'superior conjunction'. At inferior conjunction, the planet is nearest to Earth while at superior conjunction it is farthest from Earth.

The planets from Mars and beyond, the orbits of which lie outside Earth's orbit, are called the 'superior planets'. These planets come nearest to Earth at opposition when they are seen in the sky in a direction opposite that of the Sun. Further, in this position, a superior planet rises in the eastern sky as the Sun sets in the west, so the planet is visible all through the night. And if the opposition happens to be in winter when the planet is seen quite high

up in the sky, it offers the best time for observation of the planet.

Unlike the stars the positions of which in the night sky change in a regular fashion from month to month, the position of the planets does not change in any regular manner. Some of them may move by as much as 2° in a single night while others take a month or more to move the same distance. Most planets also show what is known as 'retrograde motion' Normally the planets move eastward (in the background of stars) from night to night. But during retrograde motion they appear to become stationary, move backward (that is, from east to west), become stationary again, and then resume their eastward motion. We must remember, however, that these changes occur over a span of several days or weeks; on any single day, a planet, even in retrograde motion, will rise in the east, move continuously westward and set in the west like any star. We will notice the 'backward' motion of a planet only if we watch it for several consecutive nights against the background of stars.

Because of these uncertainties about the position of the planets in the sky, it is impossible to make permanent sky maps showing their positions. But we can locate them by following the sky maps published every month in newspapers and magazines. Here are a few tips that will help us in identifying them easily.

Mercury

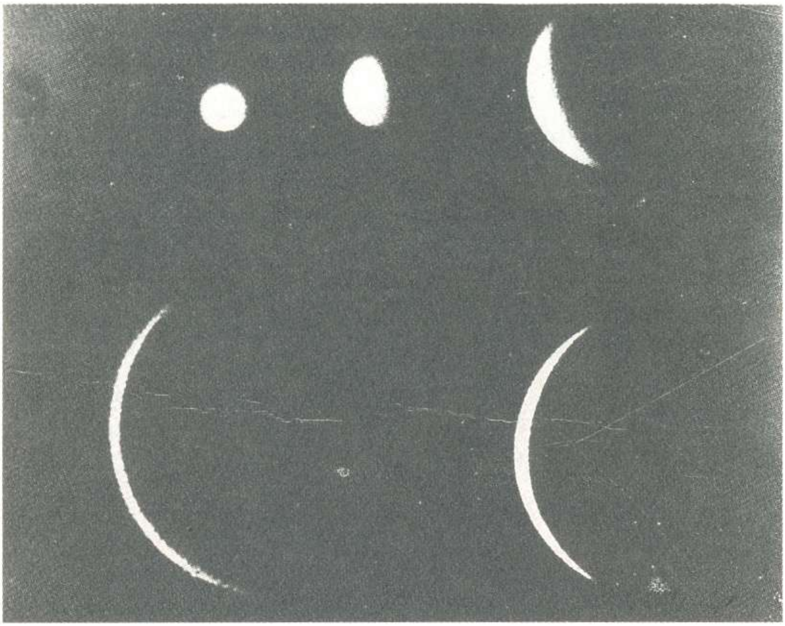
Mercury is the planet nearest to the Sun and being so near it is seldom visible, as most of the time it remains hidden behind the dazzling glare of the Sun. Theoretically, if we go by the geometry of its orbit, we should be able to see the planet at least six to seven times in a year, each time for a few weeks. But in practice, even when it is farthest away from the Sun, it appears so low in the sky that atmospheric haze at the horizon blots it out. If we have a telescope

and if we know the exact position (it can be found from the *National Ephemeris* published by the Government of India), we may be able to locate Mercury during daytime when it is in its brightest phase. As seen from Earth, the largest elongation that can be reached by Mercury is one of 28° east and west of the Sun round which it appears to oscillate, with a period amounting to about 116 days. The planet is sometimes a morning star and sometimes an evening star and is seldom visible for more than an hour after sunset or before sunrise. If we don't get to see Mercury under normal conditions we shouldn't lose heart. If we happen to be in the shadow of the Moon during a total solar eclipse, chances are that we will be rewarded by a glimpse of this elusive planet.

Venus

Venus, the second planet from the Sun, is unmistakably the brightest 'star' in the sky. It is visible for several months at a time either in the morning before sunrise or in the evening after sunset. Its magnitude varies between -4.4 and -3.3 which makes it the first 'star' to appear in the evening and the last to disappear in the morning (when not too near the Sun). Venus never moves more than 47° from the Sun and may be visible for long hours before sunrise in the morning or after sunset in the evening. If we look at Venus through a telescope we may not be able to make out much because of its dazzling brightness, but if we observe it for some months as it moves away from the Sun and again towards it, we will certainly notice that it shows phases like the Moon. When it comes between the Sun and Earth near inferior conjunction it appears much larger than when it is on the other side of the Sun in its orbit. We can then make out its beautiful crescent shape, like the crescent Moon, even with a pair of binoculars.

Both Mercury and Venus sometimes come between the Sun and Earth during inferior conjunction in such



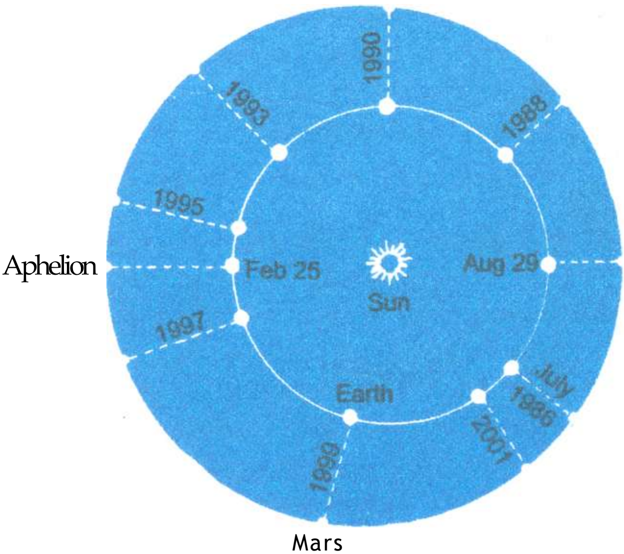
The phases of Venus as seen through telescope, when near superior conjunction (*upper left*) to near inferior conjunction (*lower left)* when it appears the largest.

a way that they can be seen as tiny black dots moving across the bright face of the Sun. The best way to see such 'transits' is by projecting an image of the Sun through a telescope on a white card and watching the slow movement of the planet across the face of the Sun. Usually such transits are publicized well in advance so that we can plan our observation accordingly.

Mars

The fourth planet from the Sun, Mars is characterised by its distinctive orange-red colour which we can make out even with the unaided eye. When at its brightest (magnitude -2.8) Mars is not difficult to locate, but at other times it weakens to magnitude +2.0 and may be difficult to find among the stars. Every two years or so, Mars comes closest to Earth in its orbit and appears much brighter than

at other times. In fact, when closest to Earth, Mars is at a distance only one-fifth of that when it is farthest away from us, which explains the large variation in its brightness.



Oppositions of Mars. A favourable opposition occurs once every 17 years when the planet comes closest to Earth.

In one month Mars moves eastward by about 15° against the background of stars. It also shows the retrograde motion. The best time to observe this planet is when it comes nearest to Earth and directly opposite the Sun which it does once in 780 days or so. At that time it rises exactly 12 hours after the Sun and is on the meridian at midnight. This is the time, called opposition, when it is the brightest and is visible all through the night.

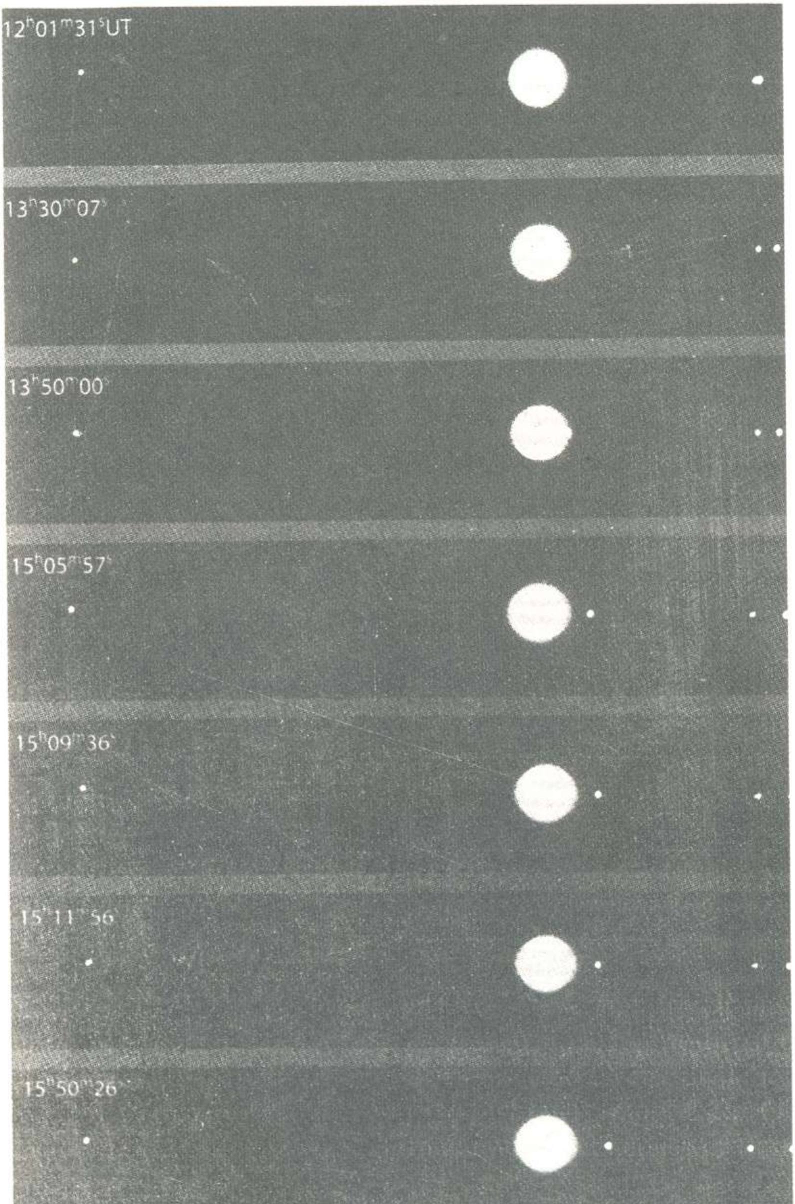
Once in every 17 years, around 29 August, during what is called a 'favourable opposition' Mars comes as close as 56 million kilometres from Earth. At this time in telescopes the planet appears almost twice as big as at

least favourable opposition when Mars is some 100 million kilometres away from Earth. Thus the best time to observe Mars through telescope is during a favourable opposition, the next of which is due in the year 2004. We cannot make out much details on Mars with binoculars or a low-power telescope, even during a favourable opposition. But if we use a telescope with a magnification greater than 200x, we may be able make out its polar caps or other markings on the surface if seeing conditions are right.

Jupiter

Jupiter, the fifth planet from the Sun, is almost always brighter than the brightest star. Once spotted it can be followed easily from year to year because it moves very slowly among the stars. In fact, in one year it moves by only 30° towards the east. Jupiter is visible near the ecliptic for about 11 months of the year. Then, for about one month, it gets too close to the Sun for observation.

Like Mars, Jupiter reaches its greatest brightness at the time of opposition which happens about once every 13 months. If we have a pair of binoculars or a small telescope we can see four of Jupiter's moons easily. Known as the Galilean moons, after the famous astronomer Galileo, they appear as tiny dots of light arranged in a line on both sides of the planet. If we keep observing for a few consecutive nights we can see the moons change position as they move around Jupiter in their own orbits. Sometimes we will find two of them on one side and two on the other while another time we may find only one on one side and three on the other. It is an exciting experience. If we have a telescope with magnification greater than 50x, we may even be able to make out two dark bands of cloud on the face of Jupiter, but if we want to see the great Red Spot, we will have to have a really powerful telescope or go to an observatory.



Jupiter through telescope. Photographs taken over a period of four hours clearly show the movement of two of the inner moons *{right).*

Saturn

Saturn is the outermost planet of the solar system visible to the naked eye. For most of the time it looks like a bright, first or second magnitude star (magnitude -0.04 to +1.4). It is visible at some time of the night for about 11 months and then disappears in the glare of the Sun for about a month. Like Jupiter, Saturn also appears to move very slowly across the background of stars. In one year it moves only by about 12° towards the east.

As we know from photographs of the planet taken with powerful telescopes, Saturn has a prominent set of rings girdling it at its equator. But the rings are not visible with the unaided eye. We can see them if we have a telescope with a magnifying power of 50x or more. An interesting thing about the rings is that they do not look the same always. As the positions of Earth and Saturn change relative to each other and the angle of slant of the rings as seen from Earth changes, the rings appear to become narrower and even disappear from view altogether. This happens when they appear edgewise as seen from Earth, once in about 15 years. The last time the rings were seen edge-on was in 1996. At present they are becoming visible again and will be seen in their best around the year **A.D.** 2003 when Saturn will also appear the brightest. If we observe Saturn through a low-power telescope and expect to find the planet as it appears in photographs, we will be greatly disappointed. With even a power of 100x we will at best see a tiny bright disc with a tiny ellipse-shaped band of rings.

Uranus, Neptune, Pluto

The outer planets Uranus and Neptune are quite large in size, but they are so far away from Earth that they appear too faint to be visible to the unaided eye. If we know exactly where to look for them (which we can find out from any popular astronomy magazine) and observe through a powerful telescope, we will see them only

as tiny dots, nothing to be excited about. The outermost planet Pluto is too small to be visible in amateur telescopes.

10

FOR A BETTER VIEW

The best way to enjoy the beauty of the star-studded night sky is to use our eyes only, without being encumbered with optical aids like binoculars and telescopes. In fact, the wide angle of vision that observation with unaided eye allows is not available if we look through a pair of binoculars or a telescope. They do allow us to see a magnified or brighter image, but at the same time drastically reduce the field of view. That is why we can never see a whole constellation (except, perhaps, a small one, such as the Crux) if we try to look through a telescope. Besides, the unaided eye allows us much more freedom for 'star-hopping'—to move from one star to another—while trying to locate a constellation, than is possible if we use an optical aid. We can also compare the difference in brightness or colour between two stars much better with unaided eye than by using binoculars or a telescope.

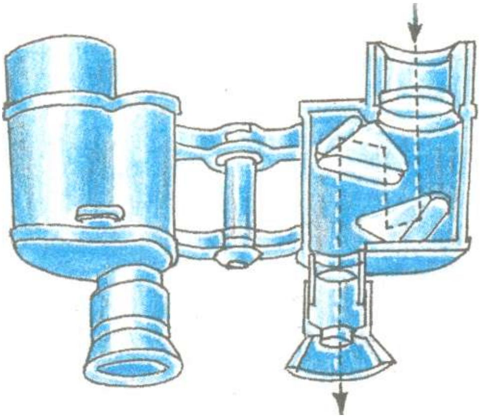
But, for all its advantages, unaided visual observation has its limitations. We can't really appreciate the majestic glory of the Milky Way, or the Orion Nebula without an optical aid. Nor can we enjoy the beauty of the Pleiades or the numerous globular clusters without a pair of binoculars or a telescope. Many double stars reveal themselves only in a telescope. But the biggest surprise we may get will be if we look at a planet like Saturn or Jupiter through a telescope. We will be amazed at what a telescope reveals. In the sky, the planets look no different

from the stars, except that, at their best Venus and Jupiter may outshine any other in the sky In a telescope we can see their distinct shapes, Jupiter's moons and Saturn's majestic rings.

Binoculars and telescopes help astronomical observation in two ways: they collect more light than the unaided eye so that even fainter objects become visible, and by magnifying the image they allow greater details to be seen clearly. The light collecting power of a pair of binoculars or a telescope is decided by the diameter of the objective lens; larger the diameter the larger is the amount of light collected and brighter will be the image. When adapted to darkness, the pupil of our eye opens up to about 7 mm in diameter. If we use binoculars or a telescope with objective lens of diameter 50 mm, it will gather 50 times more light (because it has 50 times more area than the pupil of the eye) and will show we much fainter objects (stars upto magnitude 12) than possible with unaided eye. Besides gathering more light, binoculars and telescopes also show magnified images of planets and their moons. We should remember, however, that stars will not appear bigger in a telescope because of their extremely large distances, but they will certainly appear brighter.

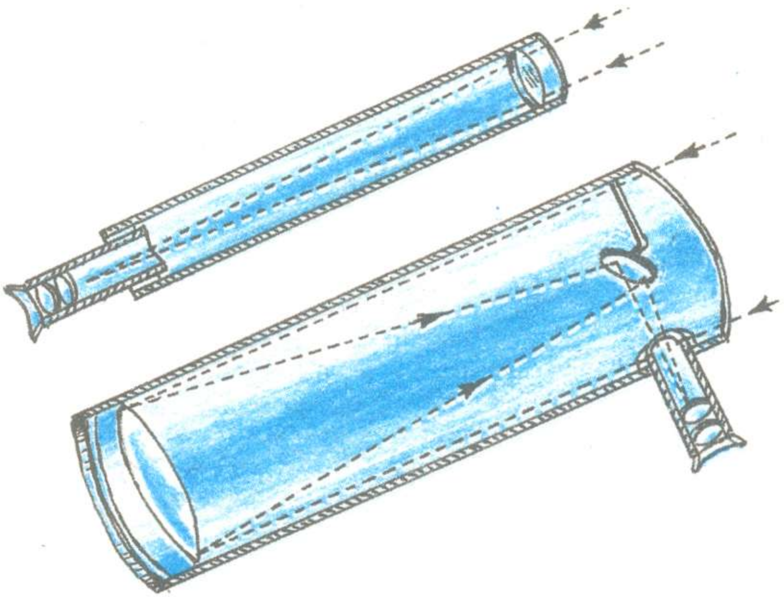
Prism binoculars are among the most convenient optical aids for skywatching. They are built in such a way that we can use both eyes for observation, which is more comfortable than squinting with one eye as we have to do when using a telescope. The small size of binoculars is made possible by the clever use of two prisms, which not only shorten the length of the instrument by folding the path of the light rays by total internal reflection, but also produce an erect image which is an advantage if we want to do some birdwatching.

Binoculars come in a wide range of sizes, with objective lens diameter ranging from 30 mm to 80 mm and magnification ranging from 7x to 20x. The power of binoculars is usually expressed as two numbers, such as



The small size of binoculars is made possible by the clever use of prisms.

8 x 30, or 10 x 50, etc. The first of these numbers denote the magnification, and the second the diameter of the objective lens. For example, an 8 x 30 has an objective lens of 30 mm diameter and will show distant objects magnified 8 times. A10 x 50 has an objective of 50 mm diameter and will magnify 10 times. We must remember that larger the objective diameter greater will be its light gathering power and brighter will be the images we see, which is a big advantage for astronomical observations. But larger the objective, bulkier the binoculars will become and this can be a big disadvantage if we want to do our observations by holding the binoculars in our hand. It is not difficult to hold a pair of 8 x 30 binoculars steady enough to be able to see without much shake. But we will find it almost impossible to hold a pair of 10 x 50 steady without some kind of support. The hand tires quickly and begins to shake, making star images jump about. Binoculars with magnification higher than lOx need some kind of mounting



Telescopes are of two types. In a refracting telescope a large-diameter lens is used as the objective *(top),* while in a reflecting telescope a concave mirror serves as the objective.

to prevent irritating shake when observing.

Binoculars are handy and excellent for observing double stars and star clusters. But we won't enjoy watching planets with them because of their low magnifying power. Binoculars will show hardly any detail on the planets, which become visible only at magnifications of 30x or more, for which we have to get a telescope.

Telescopes are basically of two types—refracting and reflecting. Refracting telescopes use combination of lenses as objective which in a reflecting telescope is replaced by a concave mirror. Refracting telescopes are usually more expensive than reflecting telescopes but are less bulky and easier to maintain than the latter. A dirty lens is much easier to clean than a front-coated mirror used in a reflecting telescope. On the other hand, a mirror of large

diameter can be made at much cheaper cost than a lens of the same diameter. And, as we may be aware, a larger diameter of the objective is always an advantage for astronomical observation. A refractor with a 3 j inch (90 mm) diameter objective will be much more expensive than a reflecting telescope with a 6-inch (150 mm) diameter mirror. Telescopes usually come with magnifications of 50x or more. In fact, when we buy a telescope, we should get a couple of additional eyepieces of different powers. We can then change the magnification by simply changing the eyepiece.

Telescopes are usually mounted on a stand in such a way that they can be pointed to any part of the sky. There are two types of mount which are widely used. The altazimuth mount is one in which we can turn the telescope both up and down and sideways independently of each other to point to a particular star or planet. In an equatorial mount, the telescope is so mounted that its axis of rotation is parallel to Earth's axis and points in a north-south direction. Any telescope will need periodic adjustment to compensate for the apparent westward movement of the sky due to Earth's rotation. With altazimuth mount we will have to adjust in both vertical and horizontal directions to keep our subject in the field of view. With an equatorial mount, on the other hand, the adjustment can be done simply by turning the telescope westward around the equatorial axis. Modern telescopes come with motorized drives which turn the telescope automatically at the right speed to compensate for Earth's rotation and keep a star or a planet in the field of view continuously.

The *Nakshatras*

Unlike the Babylonians or the Chinese, the ancient Indian astronomers were not particularly interested in the study of the stars or the preparation of star catalogues. They were more interested in the study of the motion of the Sun and the Moon through the ecliptic because it helped them in developing a workable calendar system. Their interest in stars and constellations largely centred around those which lie along or near the ecliptic. (That is why we do not have Indian names for most of the non-equatorial constellations.) By a careful selection of suitable stars and constellations they were able to develop a stellar frame of reference against which the motion of the Sun, Moon and the planets could be measured.

To account for the yearly motion of the Sun the ecliptic was divided into 12 equal parts of 30° Each part was called a *rashi* (zodiacal constellation) through which the Sun moved in one calender month. To account for the daily motion of the Moon the ecliptic was divided into 27 equal parts of 13° 20' each, called *nakshatra* or lunar house. Unlike the *rashis* which are distinctly marked by groups of stars, a *nakshatra* is simply a portion of the ecliptic not necessarily marked by prominent stars. For this reason there are no distinct stars or constellations truly corresponding to the *nakshatras.* But the ancients did select a few prominent stars or groups that may be taken as roughly equivalent to the corresponding *nakshatras* for observational purposes. Of course, except a few, they will

be difficult to locate in the sky, particularly because many of them lie far from the ecliptic. But, still, we could give it a try

The *Nakshatras*

No.	*Nakshatra (European name)*	*Star*	*Magnitude*
1.	*Asivini* (Sheratan)	β Arietis	2.64
2.	*Bharani*	41 Arietis	3.68
3.	*Krittika* (Alcyone)	η Tauri	2.87
4.	*Rohini* (Aldebaran)	α Tauri	0.85
5.	*Mrigasiras*	λ Orionis	3.66
6.	*Ardra* (Betelgeuse)	α Orionis	0.50
7.	*Punarvasu* (Pollux)	β Geminorum	1.21
8.	*Pusya*	δ Cancri	4.17
9.	*Aslesa*	α Cancri	4.27
10.	*Magha* (Regulus)	α Leonis	1.34
11.	*Purva Phalgiini* (Zosma)	δ Leonis	2.58
12.	*Uttara Phalguni* (Denebola)	β Leonis	2.53
13.	*Hasta*	δ Corvi	2.90
14.	*Chitra* (Spica)	α Virginis	0.98
15.	*Svati* (Arcturus)	α Bootis	-0.06
16.	*Visakha* (Zubenelgenubi)	α Librae	2.75
17.	*Anuradha*	δ Scorpii	2.32
18.	*Jyestha* (Antares)	δ Scorpii	0.96
19.	*Mula* (Schaula)	λ Scorpii	1.63
20.	*Purvasadha*	δ Sagittarii	2.70
21.	*Uttarasadha* (Nunki)	σ Sagittarii	2.02
22.	*Shravana* (Altair)	α Aquilae	0.77
23.	*Dhanistha*	β Delphini	3.54
24.	*Satabhisaj*	α Aquarii	2.96
25.	*Purva Bhadrapada* (Markab)	α Pegasi	2.49
26.	*Uttara Bhadrapada*	γ Pegasi	2.83
27.	*Revati*	ζ Piscium	5.57

Recommended Reading

Brown, Peter Lancaster: ***What Star is That ?*** (Thames and Hudson).

Kaler, James B.: The Ever-Changing Sky (Cambridge University Press).

Moore, Patrick: ***The Guinness Book of Astronomy: Facts & Feats*** (Guinness).

Nicholson, Ian: ***Astronomy*** (Hamlyn).

Ridpath, Ian: ***The Night Sky*** (Collins).

Ronan, C. (Ed.): ***Amateur Astronomy*** (Hamlyn).

Wace, Martin (Ed.): ***Pocket Guide to the Stars & Planets*** (Hamlyn).

Zigel, F.: ***Wonders of the Night Sky*** (Mir Publishers).

The periodical ***Sky & Telescopes,*** published monthly by Sky Publishing House, Cambridge, MA, USA, gives valuable tips on skywatching along with excellent sky maps in every issue.

The Greek Alphabet

α alpha	ι iota	ρ rho
β beta	κ kappa	σ sigma
γ gamma	λ lambda	τ tau
δ delta	μ mu	υ upsilon
ε epsilon	ν nu	π phi
ζ zeta	ξ xi	χ chi
ε eta	ο omicron	ψ psi
σ theta	π pi	ω omega

Index

Typesetting at Fine Impression, Punjabi Bagh, New Delhi -110026 and printed at Aravali Printers, W-30 Okhla Ind. Area, Phase II, New Delhi - 110020

The star-filled night sky has fascinated mankind since prehistoric times. Ancient sky-watchers imagined shapes in the pattern of bright stars that gave rise to many myths and legends. Today we know about the true nature of the stars and also about their mind-boggling distances from us. When we look at a star we actually look tens, hundreds, or even thousands of years back in time. This profusely illustrated book provides simple tips to help the reader get familiar with the constellations and identify individual stars with the help of easy-to-read star maps and diagrams.

Winner of the 1994 NCSTC National Award for best science and technology coverage in the mass media, Biman Basu (b. 1945) has been involved in science popularisation for more than three decades. An M.Sc in chemistry from the University of Delhi, he began his career as a lecturer in Hans Raj College. In 1970 he joined the Council of Scientific & Industrial Research as assistant editor of their popular science monthly, *Science Reporter* of which he is currently the editor. Between 1974 and 1977 he was on deputation to All India Radio as a science correspondent. Another of his books, *The Story of Man,* was published by NBT in 1977.

ISBN 81-237-2657-0

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